NCERT NOTES

GEOGRAPHY

11th Standard

India Physical Environment

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Unit: I

Introduction

1 India – Location

The Indian mainland extends from **Kashmir** in the **north** to **Kanyakumari** in the **south** and **Arunachal Pradesh** in the **east** to **Gujarat** in the **west**. India's territorial limit further extends towards the **sea up to 12 nautical miles (about 21.9 km)** from the coast. Our southern boundary extends up to 6°45' N latitude in the Bay of Bengal.

Location of India:

- The Longitudinal and latitudinal extent of India is about **30 degrees.**
- **North-South distance: 3214 Km**
- **East-West distance: 2933 Km**
- India with its area **of 3.28 million sq. km** accounts for **2.4 per cent** of the world's land surface area and stands as the **seventh largest country** in the world.
- **Reason behind difference between North- South and East-West extent:** The **distance** between **two longitudes decreases** towards the poles whereas the distance between **two latitudes** remains the **same** everywhere.
- **Reasons for large Variations in landforms, climate, soil types and natural vegetation:**
  - The **southern part** of the country lies within the **tropics**.
  - The **northern part** lies in the **sub-tropical** zone or the **warm temperate** zone.
- **Impact of longitudinal extent on People**:
  - Longitudinal difference is nearly 30 degrees.
  - There is **two hours difference** between easternmost and westernmost part of India.
  - This means that **sun rises two hours earlier in eastern** part than in western part.

Size of India:

- The size of India has endowed her with **great physical diversity**. It has the presence of lofty **mountains** in the north; large **rivers** such as Ganga, Brahmaputra, Mahanadi, Krishna, Godavari and Kaveri; green **forested hills** in northeast and south India; and the vast **sandy** expanse of ***Marusthali***.
- **Indian subcontinent:** It includes Pakistan, Nepal, Bhutan, Bangladesh, and India.
- The Peninsular part of India extends towards the Indian Ocean.
- The peninsular part provided India with a **coastline of 6,100 km in the mainland** and **7,517 km** in the entire geographical coast of the mainland plus the island groups Andaman and Nicobar located in the Bay of Bengal and the Lakshadweep in the Arabian Sea.

Interesting Points:

- **Standard Meridian:**
  - There is a general understanding among the countries of the world to select the standard meridian in **multiples of 7°30' of longitude**.
  - The **82°30' E** has been selected as the **'standard meridian' of India**.
  - **Indian Standard Time (IST)** is ahead of **Greenwich Mean Time (GMT)** by **5 hours and 30 minutes**.
  - There are some countries where there are **more than one standard**

meridian due to their vast east-to-west extent. For example, the **USA has seven time zones.**

- **School Bhuvan**: It is a **portal providing map-based learning** to bring awareness among the students about country's natural resources, environment and their role in sustainable development.
- **Sri Lanka** is **separated** from India by the **Gulf of Mannar** and **Palk Strait**.
- **Maldives** is located **south of Lakshadweep Island**.

Unit: II

Physiography

2 Structure and Physiography

The earth and its landforms have evolved over a very long time. The current estimation shows that the earth is approximately 460 million years old. Over these long years, it has undergone many changes brought about primarily by the endogenic and exogenic forces. These forces have played a significant role in giving shape to various surface and subsurface features of the earth.

Movement of Indian Plate:

- Indian plate was south of the equator and Australian part was part of the Indian plate million years ago.
- After the breaking, Indian plate **moved towards northern direction** and Australian plate towards southern direction.

Division of India based on its Geological Structure and Formations:

- The Peninsular Block
- The Himalayas and other Peninsular Mountains
- The Indo-Ganga-Brahmaputra Plain

The Peninsular Block:

- Its **Northern boundary** may be taken as an **irregular line** running from Kachchh, western flank of the Aravali Range to Delhi and then roughly parallel to the Yamuna and the Ganga as far as the Raajmahal Hills and the Ganga delta.
- **Extension of the Peninsular Block:**
  - **North Eastern extent**: Karbi Anglong and Meghalaya plateau
  - **Western Extent**: Rajasthan
- The **North-Eastern parts** are separated by the **Malda fault in West Bengal** from the Chotanagpur plateau.
- In **Rajasthan**, the **desert** and other desert-like features overlay this block.
- A major part of the peninsular region is formed by **complex** and **very ancient gneisses and granite**.
- Since Cambrian period, peninsular part has been standing like **rigid block**.
  - The exception is **western coast** which is **submerged beneath the sea.**
  - The other parts changed due to tectonic activity.
- As a part of the Indo-Australian plate, peninsular block is subjected to various vertical movements and block faulting. For examples, The rift valleys of Narmada, Tapi and Mahanadi and block mountain of Satpura.
- The Peninsula mostly consists of **relict and residual mountains** like the Aravali hills, the Nallamala hills, the Javadi hills, the Veliconda hills, the Palkonda range and the Mahendragiri hills, etc. and the **river valleys** are **shallow with low gradients**.
- Most of the rivers flowing towards east and **form deltas** such river Krishna, Godavari, Mahanadi forms delta.

The Himalayas and other Peninsular Mountains:

- The Himalayas along with other Peninsular mountains are **young, weak and flexible** in their geological structure unlike the rigid and stable Peninsular Block.
- Peninsular and Himalayan mountains are still subjected to interplay of endogenic and exogenic forces which resulting in the **development of faults, folds and thrust plains**.

- These mountains are **tectonic in origin**, dissected by **fast-flowing rivers** which are in their **youthful stage**.
- Various landforms like gorges, V-shaped valleys, rapids, waterfalls, etc. are indicative of this youthful stage.

Indo - Ganga - Brahmaputra Plain:

- It comprises the plain formed by **river Indus, Ganga and Brahmaputra**.
- Originally, it was a **geo-synclinal depression** which developed in third phase of Himalayan formation 64 million years ago.
- Since then, it has been **gradually filled by sediments** brought by peninsular and Himalayan rivers.
- The average depth of **alluvial deposits** is 1000 - 2000 m.

Physiography:

- 'Physiography' of an area is the outcome of structure, process and the stage of development.
- **Physical features of India**: It is characterised by:
  - The **rugged mountain topography** in **North** with various peaks, valleys and deep gorges.
  - The **Southern part** consists **stable table land** with highly dissected plateaus, denuded rocks and developed series of scarps.
  - In between these two lies the vast **north Indian plain**.

Physiographic Division of India:

- The Northern and North-Eastern Mountains
- The Northern Plain
- The Peninsular Plateau
- The Indian Desert
- The Coastal Plains
- The Islands

The North and North-Eastern Mountains:

- The North and North-eastern Mountains are **part of the Himalayas**.
- It includes **series of parallel mountain ranges** such as Greater Himalayan range, which includes the Great Himalayas and the Shiwalik.
- **General orientation of the ranges**:
  - **North-western part of India**: Northwest to the southeast direction
  - **Himalayas in the Darjeeling and Sikkim regions**: East-west direction
  - **Arunachal Pradesh**: From southwest to the northwest direction.
  - **Nagaland, Manipur and Mizoram**: North-south direction.
- The **central axial length** of the **Great Himalayan Range** is **2,500 km from east to west**, and their width varies between **160-400 km from north to south.**
- **Physical Barrier:**
  - Himalayas form **strong and long wall** between the Indian subcontinent and the Central and East Asian countries.
  - They also form **climatic, drainage and cultural barriers**.

Division of Himalayas:

It is based on relief, alignment of ranges and other geomorphological features.

- Kashmir or North-Western Himalayas
- Himachal and Uttarakhand Himalayas
- Darjeeling and Sikkim Himalayas
- Arunachal Himalayas
- Eastern Hills and Mountains

Fig. 2.1: India Physical

Kashmir or North-Western Himalayas:

- It comprises a series of ranges such as the **Karakoram, Ladakh, Zaskar** and **Pir Panjal**.
- The **cold desert** is situated in its north eastern part between the **Greater Himalaya** and the **Karakoram range**.
- The **Kashmir valley** lies between Great Himalaya and Pir Panjal range.
- **Important glaciers** of south Asia such as the **Baltoro** and **Siachen** are found in this range.
- It is famous for ***Karewa*** **formations**, which are useful for the cultivation of ***Zafran*****, a local variety of saffron.**
- **Important Passes of this region: Zoji La** on the **Great Himalayas**, **Banihal** on the **Pir Panjal, Photu La** on the **Zaskar and Khardung La** on the **Ladakh range.**
- Important **freshwater lakes** such as **Dal** and **Wular** and **saltwater** lakes such as **Pangong Tso** and **Tso Moriri** are also in this region.
- This region is drained by the **river Indus**, and its **tributaries such as the Jhelum and the Chenab**.
- This region is known for beautiful **scenic features and picturesque landscape** and this land scape is important attraction for **adventure tourists**.
- **Important Pilgrimage Sites**: Vaishno Devi, Amarnath Cave, Charar -e-Sharif, etc.
- **Srinagar** is located on the banks of **Jhelum river**.
- **Jhelum** in the valley of Kashmir is still in its **youth stage** and yet **forms meanders** – a typical feature associated with the mature stage in the evolution of fluvial landform.
- Its **southernmost part** consists of **longitudinal valleys known as 'duns'** such as Jammu dun and Pathankot dun.

Himachal and Uttarakhand Himalayas:

- It **lies between the Ravi** in the west and the **Kali** (a tributary of Ghaghara) in the east.
- It is **drained by two major river** systems of India namely the **Indus and the Ganga**.
- **Tributaries of the Indus**: Ravi, Beas and Satluj
- **Tributaries of Ganga**: Yamuna and Ghaghara
- The **Northern most part** this region is **extension of Ladakh cold desert** which lies in the Spiti subdivision of district Lahul and Spiti.
- All the **three ranges of Himalayas** are prominent in this section. These are **from North to South**:
  - The **Great Himalayan** ranges
  - The **Lesser Himalayas**: Locally known as **Dhaoladhar** in Himachal Pradesh and **Nagtibha** in Uttarakhand
  - The **Shiwalik** ranges
- The altitude is between 1,000-2,000 m specially attracted to the British colonial administration, and they established:
  - **Important Hill Stations:** Dharamshala, Mussoorie, Shimla, Kaosani
  - **Cantonment Towns and Health Resorts:** Shimla, Mussoorie, Kasauli, Almora, Lansdowne and Ranikhet, etc. were developed in this region.
- The two **distinguishing features** of this region are the **'Shiwalik'** and **'Dun formations'**.

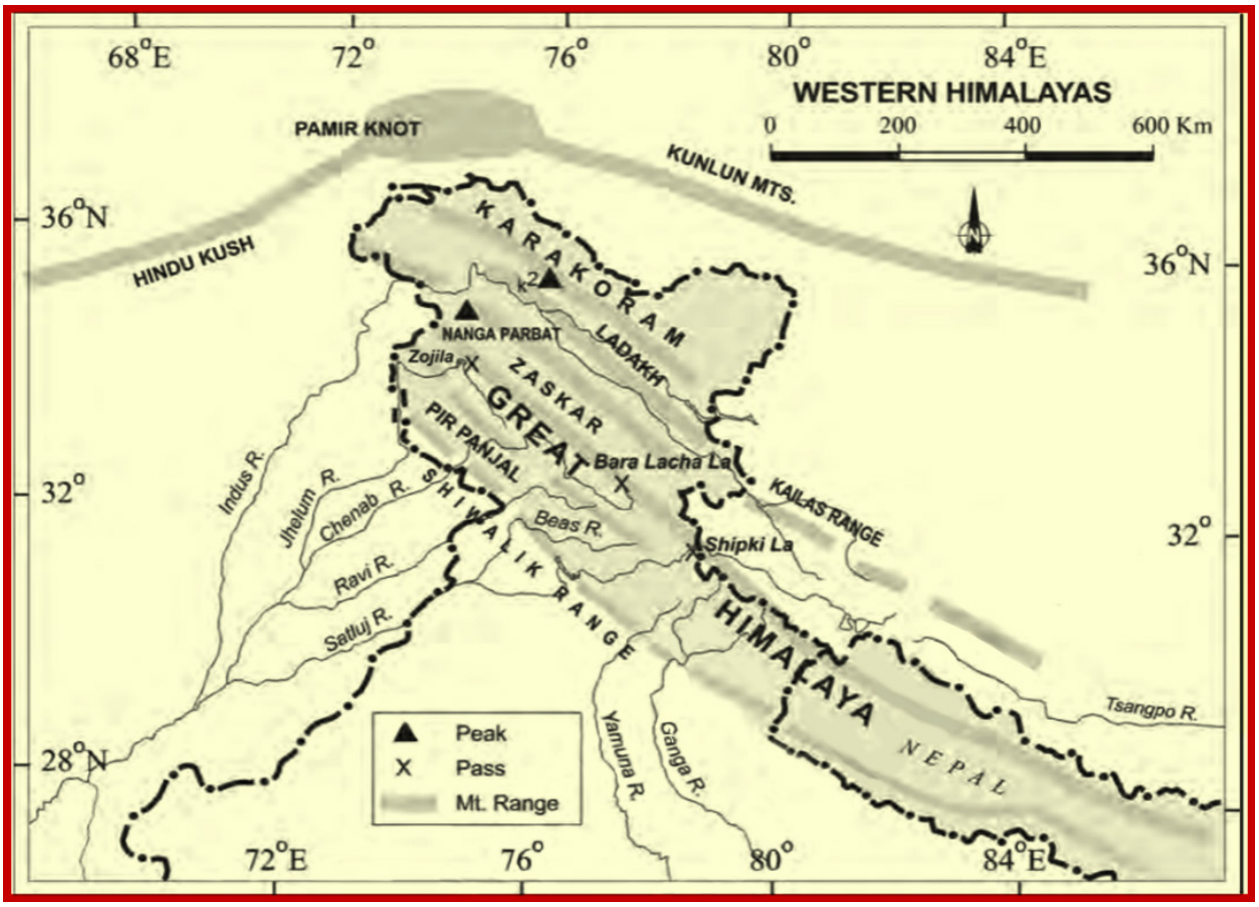

Fig. 2.2: The Western Himalayas

- **Important Duns:** Chandigarh-Kalka dun, Nalagarh dun, Dehra Dun, Harike dun and the Kota dun, etc.
- **Dehra Dun** is the **largest of all the duns** with an approximate length of 35-45 km and a width of 22-25 km.

- The Great Himalayan range the valley is mostly inhabited by **Bhotia's**. These are **nomadic groups** who migrate to **'Bugyals'** (the summer glass lands in the higher reaches) during summer months and return to the valleys during winters.
- **Valley of flower** is also situated in this region.
- **Places of Pilgrimage:** The Gangotri, Yamunotri, Kedarnath, Badrinath and Hemkund Sahib are situated in this part.
- The region is also known to have five famous Prayags (river confluences)

Darjeeling and Sikkim Himalayas:

- They are flanked by **Nepal** Himalayas in the west and **Bhutan** Himalayas in the east.

- This region is known for **fast flowing rivers** such as **Tista**.
- It is a region of **high mountain peaks** like Kanchenjunga (Kanchengiri), and deep valleys.
- The **higher reaches** of this region inhabited by **Lepcha tribes**.
- The **southern part** particularly, Darjilling Himalaya has a mixed **population of Nepalis, Bengalis and tribals from Central India.**
- The Britishers introduced **Tea plantation** in this region because of the **physical conditions**:
  - Moderate slope
  - Thick soil cover with high organic content
  - Well distributed rainfall throughout the year
  - Mild winters
- In this region, **Shiwalik formation is absent** and in place of the Shiwalik here, the **'duar formations'** are important, which have also been used for the **development of tea gardens**.
- **Sikkim** is known for its **orchids**.

Arunachal Himalayas:

- These extend from the **east of the Bhutan Himalayas** up to the **Diphu pass in the east**.
- **Important Mountain Peaks:** Kangtu and Namcha Barwa.
- These ranges are dissected by **fast-flowing rivers** from the north to the south, forming deep gorges. Brahmaputra flows through a **deep gorge after crossing Namcha Barwa**.
- **Important Rivers:** The Kameng, the Subansiri, the Dihang, the Dibang and the Lohit. These are **perennial** with the high rate of fall, thus, having the **highest hydro-electric power potential** in the country.
- **Ethnic Tribal Communities:** From West to East are the **Monpa, Abor, Mishmi, Nyishi** and the **Nagas**. Most of them **practice Jhumming cultivation**.
- Due to **rugged topography**, the inter-valley transportation linkages are nominal. Hence, most of the interactions are carried through the duar region along the Arunachal-Assam border.

Eastern Hills and Mountains:

- These are part of the Himalayan mountain system having their general alignment from the **North to the South direction**.
- They are known by **different local names**:
  - **Northern region**: Patkai Bum, Naga hills, Manipur hills
  - **Southern region**: Mizo or Lushai hills.
- These are low hills, inhabited by **numerous tribal groups** practising **Jhum cultivation**.
- Most of these ranges are separated from each other by **numerous small rivers**.
- The **Barak** is an important river in **Manipur and Mizoram** and other rivers of both states forms tributaries of Barak which turns tributary of **Meghana**.
- **Loktak lake in Manipur** is surrounded by mountains is a unique feature.
- The rivers in the eastern part of Manipur are the tributaries of **Chindwin**, which in turn is a tributary of the **Irrawaddy of Myanmar**.
- **Mizoram** which is also known as the **'Molassis basin'** which is made up of **soft unconsolidated deposits**.
- Most of the rivers in Nagaland form the tributary of the Brahmaputra.

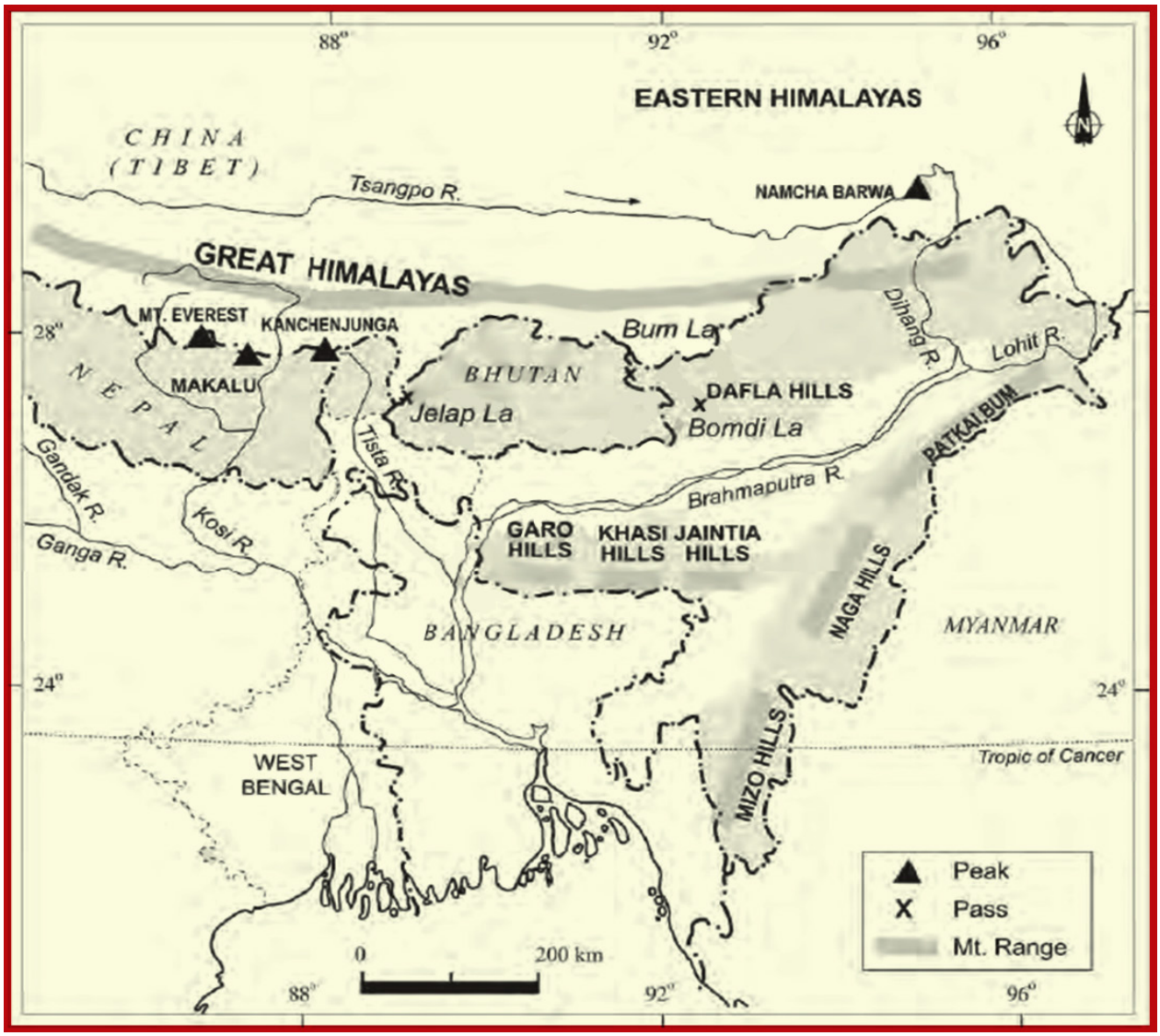

Fig. 2.3: The Eastern Himalayas

The Northern Plains:

- They are formed by the **alluvial deposits** brought by the rivers – **the Indus, the Ganga and the Brahmaputra.**
- Its length is 3200 km from east to west, average width varies from 150-300 Km and the maximum depth is between 1000-2000 m.
- From the north to the south, these can be divided into **three major zones**: **The Bhabar, the Tarai and the alluvial plains**. The **alluvial plains** can be further divided into **the Khadar and the Bhangar.**
  - **Bhabar:**
    - It is a **narrow belt** ranging between 8-10 km **parallel to the**

Shiwalik foothills at the break-up of the slope.
    - The **streams and rivers** coming from the mountains **deposit heavy materials of rocks and boulders**, and at times, **disappear in this zone**.
  - **Tarai:**
    - It lies **South of the Bhabar** with an approximate width of 10-20 km.
    - Most of the **streams and rivers re-emerge** without having any properly demarcated channel, thereby, creating **marshy and swampy conditions** known as the **Tarai**.
    - This has a **luxurious growth of natural vegetation** and houses a varied **wildlife**.
  - The south of Tarai is a belt consisting of **old and new alluvial** deposits known as the **Bhangar and Khadar** respectively.
- These plains have characteristic features of **mature stage of fluvial** erosional and depositional landforms such as **sand bars, meanders, oxbow lakes and braided channels**.
- The **Brahmaputra plains** are known for their **riverine islands and sand bars**. Most of these areas are subjected to **periodic floods and shifting river courses** forming braided streams.
- The states of **Haryana and Delhi** form a **water divide** between the Indus and the Ganga river systems.
- **Brahmaputra** river flows from the **northeast to the southwest** direction before it takes an almost 90° southward turn at **Dhubri** before it **enters into Bangladesh**.
- These river valley plains have a **fertile alluvial soil** cover which supports a variety of crops like wheat, rice, sugarcane and jute, and hence, supports a large population.

The Peninsular Plateau:

- Rising from the height of 150 m above the river plains up to an elevation of 600-900 m is the **irregular triangle** known as the **Peninsular plateau**.
- **Extent**:
  - **Northwest: Delhi ridge** (extension of Aravalis)
  - **East: Rajmahal hills**
  - **West: Gir range**
  - **South: Cardamom hills** constitute the outer extent of the Peninsular plateau.
- It is made up of a series of **patland plateaus** such as the Hazaribagh plateau, the Palamu plateau, the Ranchi plateau, the Malwa plateau, the Coimbatore, plateau and the Karnataka plateau, etc.
- The **general elevation** of the plateau is from the **west to the east**.
- **Important Physiographic Features:** Tors, block mountains, rift valleys, spurs, bare rocky structures, series of hummocky hills and wall-like quartzite dykes offering natural sites for water storage.
- The **western and north-western part** of the plateau has an emphatic presence of **black soil**.
- It has gone from recurrent phases of **upliftment and submergence** such as **Bhima fault**.
- The **north-western part** of the plateau has a complex relief of **ravines and gorges** such as the ravines of **Chambal, Bhind and Morena**.

- On the basis of the prominent relief features, the Peninsular plateau can be divided into **three broad groups: The Deccan Plateau, The Central Highlands, The North-eastern Plateau.**

The Deccan Plateau:

- This is bordered by the Western Ghats in the west, Eastern Ghats in the east and the Satpura, Maikal range and Mahadeo hills in the north.
- **Western Ghats are locally known** by different names:
  - **Sahyadri** in Maharashtra.
  - **Nilgiri hills** in Karnataka and Tamil Nadu.
  - **Anaimalai hills** and **Cardamom hills** in Kerala.
- **Western ghats are higher in elevation and more continuous**.
  - Average elevation is about 1,500 m with the **height increasing from north to south**.
  - **Anaimudi (2,695 m)**, the **highest peak of peninsular region** followed by **Dodabetta** (2,637 m) on the **Nilgiri hills**.
- The **Eastern Ghats** comprising the **discontinuous** and **low hills** are **highly eroded by the rivers** such as the Mahanadi, the Godavari, the Krishna, the Kaveri, etc.
- The **Eastern and the Western Ghats meet each other at the Nilgiri hills**.

The Central Highlands:

- They are bounded to the west by the Aravali range.
- The **Satpura range** is formed by a series of scarped plateaus on the south generally at an elevation varying between 600-900 m above the mean sea level.
  - This forms the **northernmost boundary of the Deccan plateau**.
  - It is a classic example of the **relict mountains** which are highly denuded and form discontinuous ranges.
- The **western region** of this peninsular part has undergone **metamorphic processes** in its geological history, which can be corroborated by the presence of metamorphic rocks such as marble, slate, gneiss, etc.
- The **general elevation** of the Central Highlands ranges between 700-1,000 m above.
- It **slopes towards the north and north-eastern** directions.
- Most of the **tributaries of the river Yamuna** have their origin in the **Vindhyan and Kaimur ranges.**
- **Banas** is the only **significant tributary of the river Chambal** that originates from the **Aravalli** in the west.
- An **eastern extension** of the Central Highland is formed by the **Rajmahal hills**, to the south of which lies a large reserve of **mineral resources in the Chotanagpur plateau**.

The North-Eastern Plateau:

- It is **extension of peninsular plateau**.
- It is believed that due to the force exerted by the north-east ward movement of the Indian plate at the time of the Himalayan origin, a **huge fault** was created between the Rajmahal hills and the Meghalaya plateau.
- The Meghalaya plateau is further sub-divided into three regions: **The Garo Hills; The Khasi Hills; The Jaintia Hills**.

An extension of this is also seen in the **Karbi Anglong hills** of Assam.

- The Meghalaya plateau is also **rich in mineral resources** like coal, iron ore, sillimanite, limestone and uranium.
- This area receives **maximum rainfall from the south west monsoon**.
  - As a result, the **Meghalaya plateau** has a **highly eroded surface**.
  - **Cherrapunji** displays a bare rocky surface devoid of any permanent vegetation cover.

The Indian Desert:

- It lies to the **northwest of the Aravali hills**.
- It is a land of **undulating topography** dotted with **longitudinal dunes and barchans**.
- During the **Mesozoic era**, this region was **under the sea**.
  - This can be corroborated by the evidence available at **wood fossils park** at Aakal and marine deposits around Brahmsar, near Jaisalmer.
- **Desert land Features:** Mushroom rocks, shifting dunes and oasis (mostly in its southern part).
- The desert can be divided into **two parts based on the orientation**:
  - **Northern** part: Slopes towards Sindh.
  - **Southern** part: Slopes towards Rann of Kachchh.
- Most of the **rivers are ephemeral**.
- The **Luni river** flowing in the southern part of the desert is of some significance.
- This region presents a typical case of **inland drainage** by joining a **lake or playa**.
- The lakes and the playas have **brackish water** which is the main source of **obtaining salt**.

Coastal Plains:

On the basis of the location and active geomorphological processes, it can be broadly divided into two regions:

The Western Coastal Plains:

- It is **submerged coastal plain**.
- Due to submergence, it is a narrow belt and provides **natural conditions** for the **development of ports and harbours** such as Kandla, Mazagaon, JLN port Navha Sheva, Marmagao, Mangalore, Cochin, etc.
- It may be divided into following **divisions**:
  - **Kachchh and Kathiawar coast** in Gujarat.
  - **Konkan coast** in Maharashtra.
  - **Goan coast** and **Malabar coast** in Karnataka and Kerala respectively.
- They are **narrow in the middle** and get **broader towards north and south**.
- The **Malabar coast** has got certain distinguishing features in the form of **'Kayals'** (**backwaters**), which are used for **fishing, inland navigation**.
- Every year the famous **Nehru Trophy Vallamkali** (boat race) is held in **Punnamada Kayal** in Kerala.

The Eastern Coastal Plains:

- These are **broader** and are an example of an **emergent coast**.
- There are **well developed deltas** formed by the rivers flowing eastward into the Bay of Bengal.
- It has a **smaller number of ports and harbours**. The continental shelf extends

up to 500 km into the sea, which makes it difficult for the development of good ports and harbours.

The Islands:

There are two major island groups in India, one in the Bay of Bengal and the other in the Arabian Sea.

The Bay of Bengal island groups:

- It consists of about **572 islands/islets** and are situated roughly between 6°N-14°N and 92°E -94°E.
- The **two principal groups** of islets include the **Ritchie's archipelago** and the **Labrynth island**.
- The **Andaman and Nicobar are separated** by a water body called which is **ten-degree channel.**
- These islands are an **elevated portion of submarine mountains**.
- **Barren island**, the **only active volcano in India** is also situated in the **Nicobar Islands**.
- These islands receive **convectional rainfall** and have an **equatorial type of vegetation**.

The Islands of the Arabian Sea:

- It includes **Lakshadweep and Minicoy**.
- These are scattered between 8°N-12°N and 71°E -74°E longitude.
- These islands are located of 280 km-480 km **off the Kerala coast**.
- The entire island group is built of **coral deposits**.
- There are approximately **36 islands of which 11 are inhabited**.
- **Minicoy is the largest island** with an area of 453 sq. km.
- The entire group of islands is broadly **divided by the Ten-degree channel**, north of ten-degree channel Amini island and south of it Cannanore island is situated.
- The Islands of this archipelago have storm beaches consisting of unconsolidated pebbles, shingles, cobbles and boulders on the eastern seaboard.

Interesting Points:

- **Karewas:** These are the **thick deposits of glacial clay** and other materials embedded with moraines.
- In Kashmir Valley, the meanders in Jhelum river are caused by the local base level provided by the erstwhile larger lake of which the present **Dal Lake** is a small part.
- Some important **mountain peaks in Andaman and Nicobar Islands**:
  - Saddle peak (North Andaman – 738 m)
  - Mount Diavolo (Middle Andaman – 515 m)
  - Mount Koyob (South Andaman – 460 m)
  - Mount Thuiller (Great Nicobar – 642 m)

3 Drainage System

The flow of water through **well-defined channels** is known as '**drainage'** and the **network of such channels** is called a '**drainage system'**. The drainage pattern of an area is the outcome of the geological time period, nature and structure of rocks, topography, slope, amount of water flowing and the periodicity of the flow.

Figure 3.1: Major Rivers of India

Important Terms related to Drainage:

- A river drains the water collected from a specific area, which is called its **'catchment area'**.
- An area drained by a river and its tributaries is called a **drainage basin**.
- The boundary line separating one drainage basin from the other is known as the **watershed**.
- The catchments of large rivers are called **river basins** while those of small rivulets and rills are often referred to as **watersheds**. **Watersheds are small in area while the basins cover larger areas.**

Division of Indian Drainage System:

- **On the basis of Discharge of water** (orientations to the sea):
  - It may be grouped into the **Arabian Sea drainage**, and the **Bay of Bengal drainage**.
  - They are **separated** from each other through the **Delhi ridge, the Aravalis and the Sahyadris.**
- **On the basis of the size of the Watershed**:
  - **Major River Basins**: It has **more than 20,000 sq. km of catchment area**. It includes **14 drainage basins** such as the Ganga, the Brahmaputra, the Krishna, the Tapi, the Narmada, the Mahi, the Pennar, the Sabarmati, the Barak, etc.
  - **Medium River Basins:** It has **catchment area between 2,000-20,000 sq. km** and incorporate **44 river basins** such as the Kalindi, the Periyar, the Meghna, etc.
  - **Minor River Basins:** It has catchment area of **less than 2,000 sq. km** and include fairly good number of rivers flowing in the area of low rainfall.

Drainage Systems of India:

- The most accepted classification is **Himalayan drainage system and Peninsular drainage system.**
- Indian drainage system consists of a large number of small and big rivers.
- It is the **outcome of the evolutionary process** of the three major physiographic units and the nature and characteristics of precipitation.

Himalayan Drainage System:

- The Himalayan drainage system has evolved through a long geological history.
- It mainly includes the **Ganga, the Indus and the Brahmaputra river basins**. These rivers are flowing from large gorges which is carved out by the erosional activity carried on simultaneously with the uplift of the Himalayas.
- These rivers form **deep gorges, V-shaped valleys, rapids and waterfalls** in their mountainous course.
- While **entering the plains**, they form **depositional features** like flat valleys, ox-bow lakes, flood plains, braided channels, and deltas near the river mouth.
- In the **Himalayan reaches**, the course of these rivers is **highly tortous**, but over the **plains** they display a **strong meandering tendency** and shift their courses frequently.

- **River Kosi**, also known as the **'sorrow of Bihar'**, has been notorious for frequently changing its course. As this river brings huge quantity of sediments and deposit on its plains consequently course gets blocked.

Evolution of Himalayan Drainage System:

- During the **Miocene period** some 5-24 million years ago, the river Shiwalik or Indo-Brahma traversed the entire longitudinal extent of the Himalaya from Assam to Punjab and onwards to Sind, and finally discharged into the Gulf of Sind near lower Punjab.
- The remarkable continuity of the Shiwalik and its lacustrine origin and alluvial deposits consisting of sands, silt, clay, boulders and conglomerates support this viewpoint.
- Indo-Brahma river was dismembered into **three main drainage systems**:
  - The **Indus** and its five tributaries in the western part.
  - The **Ganga** and its Himalayan tributaries in the central part.
  - The **Brahmaputra** in Assam and its Himalayan tributaries in the eastern part.
- This dismemberment due to **Pleistocene upheaval** in the western Himalayas and uplift of **Potawar plateau (Delhi ridge),** which acted as **water divide** between **Indus and Ganga** river system.
- Also, down thrusting of **Malda gap** in mid Pleistocene period **diverted the Ganga and the Brahmaputra** systems to flow **towards the Bay of Bengal**.

River System of Himalayan Drainage

The Indus River System:

- It is **one of the largest river basins** of the world, covering an area of 11,65,000 sq. km **(in India it is 321, 289 sq. km)** and a total length of 2,880 km **(in India 1,114 km).**
- It is the **western most Himalayan river** of the India and **in Tibet** it is known as **'Singi Khamban**, or **Lion's mouth**.
- It **originates** from a **glacier near Bokhar Chu** (31°15' N latitude and 81°40' E longitude) in the Tibetan region at an altitude of 4,164 m in the **Kailash Mountain range**.
- It flows **North-West direction** between Ladakh and Zaskar range and passes through Ladakh and Baltistan region.
- It cuts across the Ladakh range and **forms gorge near Gilgit** in Jammu and Kashmir.
- It **enters Pakistan** near Chilas in the Dardistan region.
- **Left Bank Tributaries:** Zaskar, Suru, Jhelum, Chenab, Ravi, Beas and Satluj, etc.
- **Right Bank Tributaries:** Shyok, Hunza, Nubara, Kabul, Khurram, Gomal, Tochi, The Viboa and the Sangar, etc.
- It finally **emerges out of the hills near Attock** where it receives the **Kabul river** on its right bank.
- The river **flows southward** and receives **'Panjnad'** a little above **Mithankot**.
- The **Panjnad** is the name given to the **five rivers of Punjab**, namely the Satluj, the Beas, the Ravi, the Chenab and the Jhelum.

- Indus flows in India **only through Jammu and Kashmir**.

Tributaries of the Indus

Jhelum:

- It **rises from a spring at Verinag** situated at the **foot of the Pir Panjal** in the south-eastern part of the valley of Kashmir.
- It flows **through Srinagar and the Wular lake** before entering Pakistan through a deep narrow gorge.
- It **joins the Chenab** near Jhang in Pakistan.

Chenab:

- It is the **largest tributary of the Indus.**
- It is formed by **two streams, the Chandra and the Bhaga**, which join at Tandi near Keylong in **Himachal Pradesh**. Hence, it is also known as **Chandrabhaga**.
- The river flows for 1,180 km before entering Pakistan.

Ravi:

- It rises **west of the Rohtang pass** in the **Kullu hills** of **Himachal Pradesh** and flows through the **Chamba valley** of the state.
- Before entering Pakistan and **joining the Chenab** near Sarai Sidhu, it drains the area lying between the south-eastern part of the Pir Panjal and the Dhauladhar ranges.

Beas:

- It originates **from the Beas Kund near the Rohtang Pass** at an elevation of 4,000 m above the mean sea level.
- The river flows through the **Kullu valley** and **forms gorges at Kati and Largi** in the Dh**aoladhar range**.
- It enters the Punjab plains where it **meets the Satluj near Harike**.

Satluj:

- It originates in the **'Raksas tal' near Mansarovar** at an altitude of 4,555 m in Tibet where it is known as **Langchen Khambab**.
- It flows **almost parallel to the Indus** for about 400 km before entering India and comes out of a **gorge at Rupar**.
- It passes through the **Shipki La** on the Himalayan ranges and enters the Punjab plains**.**
- It is an **antecedent river**.
- It is a very important tributary as it feeds the canal system of the **Bhakra Nangal project.**

The Ganga System:

- The Ganga is the **most important river** of India both from the point of view of its basin and cultural significance.
- It **rises in the Gangotri glacie**r near Gaumukh (3,900 m) in the Uttarkashi district of Uttarakhand. Here, it is known as the **Bhagirathi**.
- It cuts through the Central and the Lesser Himalayas in **narrow gorges**.
- At **Devprayag**, the **Bhagirathi meets the Alaknanda**; hereafter, it is **known as the Ganga**.
- The **Alaknanda** has its source in the **Satopanth glacier above Badrinath**. Important **Prayags** where other rivers meet Alaknanda are:

- **Vishnu Prayag** or Joshimath: Alaknanda consists of the Dhauli and the Vishnu Ganga which meet here.
- **Karna Prayag**: Pindar joins Alaknanda.
- **Rudra Prayag**: Mandakini or Kali Ganga meets Alaknanda.

- The **Ganga enters the plains at Haridwar**. After this, it flows first to the south, then to the south-east and east.
- It has a length of 2,525 km. It is shared by Uttarakhand (110 km) and Uttar Pradesh (1,450 km), Bihar (445 km) and West Bengal (520 km).
- The Ganga basin covers about **8.6 lakh sq. km** area in India.
- The **Ganga river system** consist of rivers **originating from both peninsula and Himalayas**.
- **Left Bank Tributaries:** Ramganga, Gomati, Ghaghara, Gandak, Kosi and Mahananda
- **Right Bank Tributaries:** Son, Punpun and Damodar

Tributaries of Ganga river

Yamuna:

- It is the **western** most and the **longest tributary of the Ganga** and has its **source in the Yamunotri glacier** on the western slopes of Banderpunch range (6,316 km).
- It **joins the Ganga at Prayagraj (Allahabad).**
- **Right Bank Tributaries:** Chambal, Sind, Betwa and Ken.
- **Left Bank Tributaries:** Hindan, Rind, Sengar, the Varuna.

Chambal:

- It rises **near Mhow** in the **Malwa plateau** of Madhya Pradesh and flows through a gorge up wards of Kota in Rajasthan, where the **Gandhisagar dam** has been constructed.
- From Kota, it traverses down to Bundi, Sawai Madhopur and Dholpur, and **finally joins the Yamuna.**
- The Chambal is famous for its **badland topography** called the **Chambal ravines**.

Gandak:

- It comprises **two streams**, namely **Kaligandak and Trishulganga**.
- It rises in the **Nepal Himalayas** between the Dhaulagiri and Mount Everest and drains the central part of Nepal.
- It enters the Ganga plain in Champaran district of Bihar and **joins the Ganga at Sonpur near Patna.**

Ghaghara:

- It originates in the **glaciers of Mapchachungo**. After collecting the waters of its tributaries – Tila, Seti and Beri, it comes out of the mountain, cutting a **deep gorge at Shishapani**.
- The **river Sarda** (Kali or Kali Ganga) joins it in the plain before it finally **meets the Ganga at Chhapra.**

Kosi:

- It is an **antecedent river** with its source to the **north of Mount Everest in Tibet**, where its **main-stream Arun** rises.
- After crossing the Central Himalayas in Nepal, it is **joined by the Son Kosi** from the West and the **Tamur Kosi** from the east.
- It forms **Sapt Kosi** after uniting with the river Arun.

Ramganga:

- It is comparatively **a small river** rising in the Garhwal hills near Gairsain.
- It changes its course to the southwest direction after crossing the Shiwalik and enters into the plains of Uttar Pradesh near Najibabad.
- Finally, it **joins the Ganga near Kannauj**.

Damodar:

- It occupies the eastern margins of the Chotanagpur Plateau where it flows through a rift valley and finally **joins the Hugli**.
- The **Barakar** is its **main tributary**.
- Once known as the '**sorrow of Bengal'**, the Damodar has been now tamed by the **Damodar Valley corporation**, a multipurpose project.

Sarda or Saryu river:

- It rises in the **Milam glacier** in the Nepal Himalayas where it is known as the **Goriganga**.
- Along the Indo-Nepal border, it is called **Kali or Chauk**, where it **joins the Ghaghara**.

Mahananda:

- It is another important tributary of the Ganga rising in the **Darjilling hills**.
- It joins the Ganga as its last **left bank tributary** in **West Bengal**.

Son:

- It Is a large south bank tributary of the Ganga, originating in the **Amarkantak plateau**.
- After forming a series of waterfalls at the edge of the plateau, it reaches **Arrah, west of Patna, to join the Ganga**.

The Brahmaputra System:

- The Brahmaputra, one of the largest rivers of the world, has its **origin in the Chemayungdung glacier** of the **Kailash range near the Mansarovar lake**.
- Then it **travels eastward longitudinally** for a distance of nearly 1,200 km in a dry and flat region of southern Tibet, where it is known as the **Tsangpo**, which means 'the purifier'.
- The **Rango Tsangpo** is the major **right bank tributary of this river in Tibet**.
- It emerges out by carving out a **deep gorge** in the Central Himalayas near Namcha Barwa (7,755 m).
- The river emerges from the foothills under the name of **Siang or Dihang**.
- It **enters India** west of **Sadiya town in Arunachal Pradesh**.
- **Left Bank Tributaries:** Burhi Dihing and Dhansari (South)
- **Right Bank Tributaries:** Subansiri, Kameng, Manas and Sankosh
- **The Subansiri** which has its origin **in Tibet**, is an **antecedent river.**
- The Brahmaputra **enters into Bangladesh near Dhubri** and flows southward.
    - In Bangladesh, the **Tista** joins it on its **right bank** from where the river is known as the **Jamuna**.
    - It finally **merges with the river Padma**, which falls in the Bay of Bengal.
- The Brahmaputra is well-known for **floods, channel shifting and bank erosion** because the fact that most of its tributaries are large and bring large quantity of sediments owing to heavy rainfall in its catchment area.

The Peninsular River System:

- The Peninsular drainage system is **older than the Himalayan one**. This is evident from the broad, largely graded shallow valleys, and the maturity of the rivers.
- Most of the major **Peninsular rivers except Narmada and Tapi flow from west to east**.
- The **Western Ghats** act as the **water divide between west and east flowing rivers**.
- The Chambal, the Sind, the Betwa, the Ken, the Son, originating in the northern part of the Peninsula belong to the **Ganga river system**.
- The major river systems of the **Peninsular drainage** are the Mahanadi the Godavari, the Krishna and the Kaveri.
- Peninsular rivers are characterised by fixed course, absence of meanders and nonperennial flow of water. The Narmada and the Tapi which flow through the rift valley are, however, exceptions.

Evolution of Peninsular Drainage System: Three major geological events of past have shaped the present drainage systems of Peninsular India:

- **Subsidence of the Western part of the Peninsula:**
  - It leads to its **submergence below the sea** during the early tertiary period.
  - It has disturbed the symmetrical plan of the river on either side of the original watershed.
- **Upheaval of the Himalayas:**
  - When the northern flank of the Peninsular block was subjected to subsidence and the consequent **trough faulting**.
  - The **Narmada and the Tapi** flow in trough faults and fill the original cracks with their detritus materials. Hence, there is a **lack of alluvial and deltaic deposits** in these rivers.
- **Slight tilting of the Peninsular Block:**
  - From northwest to the south-eastern direction gave orientation to the entire drainage system towards the Bay of Bengal during the same period.

River Systems of the Peninsular Drainage

Mahanadi:

- It **rises near Sihawa** in Raipur district of **Chhattisgarh** and **runs through Odisha** to discharge its water **into the Bay of Bengal.**
- It is 851 km long and its catchment area spreads over 1.42 lakh sq. km.
- Some **navigation** is carried on in the **lower course** of this river.
- 53 per cent of the drainage basin of this river lies in Madhya Pradesh and Chhattisgarh, while 47 per cent lies in Odisha.

Godavari

- Godavari is the **largest Peninsular river system**. It is also called the **Dakshin Ganga**.
- It **rises in the Nasik** district of **Maharashtra** and discharges its water into the Bay of Bengal.
- Its tributaries run through the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Odisha and Andhra Pradesh.

- It is 1,465 km long with a catchment area spreading over 3.13 lakh sq. km of which 49 per cent of this, lies in Maharashtra, 20 per cent in Madhya Pradesh and Chhattisgarh, and the rest in Andhra Pradesh.
- **Left Bank Tributaries:** Banganga, Kadva, Shivana, Purna, Kadam, Pranahita, Indravati, Taliperu, Sabari, Dharna.
- **Right Bank Tributaries:** Nasardi, Pravara, Sindphana, Manjira, Manair, Kinnerasani.
- The **Godavari is subjected to heavy floods** in its lower reaches to the south of Polavaram, where it forms a picturesque **gorge**.
- It is **navigable only in the deltaic stretch**.
- The river **after Rajamundri splits** into several branches forming a large delta.

Krishna:

- It is the **second largest east-flowing** Peninsular river which **rises near Mahabaleshwar** in Sahyadri.
- Its total length is 1,401 km.
- **Left Bank Tributaries:** Bhima, Dindi, Peddavagu, Musi, Paleru, Munneru.
- **Right Bank Tributaries:** Koyana, Venna, Panchganga, Dhudhganga, Ghataprabha, Malaprabha and Tungabhadra.
- Out of the total catchment area of the Krishna, 27 per cent lies in Maharashtra, 44 per cent in Karnataka and 29 per cent in Andhra Pradesh and Telangana.

Kaveri:

- It **rises in Brahmagiri hills** (1,341m) of Kogadu district in **Karnataka**.
- Its length is 800 km, and it drains an area of 81,155 sq. km.
- The river carries **water throughout the year** with comparatively less fluctuation than the other Peninsular rivers.
  - Upper catchment area receives rainfall during the **southwest monsoon** season (summer).
  - Lower part during the **northeast monsoon** season (winter).
- About **3 per cent of the Kaveri basin falls in Kerala**, 41 per cent in Karnataka and 56 per cent in Tamil Nadu.
- **Left Bank Tributaries:** Herangi, Hemvati, Shimsha, Akravaty etc.
- **Right Bank Tributaries:** Kabini, Bhavani, Amravati, Lakshmana tirtha, Noyyal etc.

Narmada:

- It **originates** on the **western flank of the Amarkantak plateau** at a height of about 1,057 m.
- **Flowing in a rift valley** between the **Satpura** in the south and the **Vindhyan** range in the north, it forms a picturesque **gorge in marble rocks** and **Dhuandhar waterfall** near Jabalpur.
- After flowing a distance of about 1,312 km, it **meets the Arabian sea south of Bharuch**, forming a broad 27 km long estuary.
- Its catchment area is about 98,796 sq. km.
- The **Sardar Sarovar Project** has been constructed on this river.

Tapi:

- It originates from Multai in the **Betul district of Madhya Pradesh**.
- It is 724 km long and drains an area of 65,145 sq. km.
- Nearly 79 per cent of its basin lies in Maharashtra, 15 per cent in Madhya

Pradesh and the remaining 6 per cent in Gujarat.

Luni:

- It is the **largest river system of Rajasthan** and flows **west of Aravali**.
- It **originates near Pushkar** in two branches, i.e**., the Saraswati and the Sabarmati**.
  - These rivers join each other at Govindgarh.
  - At **Govindgarh**, the river comes out of Aravali and is **known as Luni**.
- It flows towards the west till Telwara and then takes a southwest direction to join the Rann of Kuchchh.
- The entire river system is **ephemeral**.

Some West flowing Rivers: The rivers flowing **towards the Arabian sea** have short courses.

In Gujarat:

- Shetruniji rises near Dalkahwa in Amreli district.
- Bhadra originates near Aniali village in Rajkot district.
- **Sabarmati and Mahi are the two famous rivers of Gujarat**.
- Dhadhar rises near Ghantar village in Panchmahal district.

In Maharashtra: Vaitarna rises from the Trimbak hills in Nasik district at an elevation of 670 m.

In Karnataka:

- **Kalinadi** rises from Belgaum district and falls in the Karwar Bay.
- **Bedti** source lies in Hubli Dharwar and it has course of 161 km.
- **Sharavati** originates in Shimoga district of Karnataka and drains a catchment area of 2,209 sq. km.

In Goa: It has two important rivers, **Mandovi** and **Juari.**

In Kerala:

- **Bharathapuzha** rises near **Annamalai hills**. It is also known as **Ponnani**. It drains an area of 5,397 sq. km. It is the **longest river of Kerala**.
- **Periyar** is the **second largest** river **of Kerala**. Its catchment area is 5,243 sq. km.
- **Pamba** falls in the **Vemobanad lake** after traversing a course of 177 km.

Rivers	Catchment area (in sq km)
Mahi	34,832
Sabarmati	21,674
Bharathapuzha	5,397
Periyar	5,247
Kalinadi	5,179
Dhandhar	2,770
Sharavati	2,029

Some East Flowing Rivers: There are small rivers which join the Bay of Bengal.

In Jharkhand: Subarnrekha rises over Chota Nagpur plateau, Jharkhand.

In Odisha:

- **Baitarni** rises in the hills of Kendhujhar, Odisha.
- **Brahmani** is formed by two streams the river south Koel and Sankh join near Rourkela and then it is called Brahmani river.
- **Vamsadhara** originate on southern part of Odisha and it flows through Andhra Pradesh.

In Karnataka:

- **Penner**:
  - The **northern Pennar** originate from Nadidurga Karnataka and it flows through Andhra Pradesh.
  - The **southern Pennar** rises from Keshav hills of Karnataka. It flows south to the northern Pennar and drains into Bay of Bengal.
- **Palar** rises from Kolar district of Karnataka and flows through Andhra Pradesh and Tamil Nadu. The river Poini and Cheyyar are two important tributaries.

In Tamil Nadu: Vaigai rises from hills of Varshanand hills of Mdhurai. It drains into Palk strait.

Rivers	Catchment area in sq.km
Pennar	55,213
Brahmani	39,033
Subarnarekha	19,296
Palar	17,870
Baitarni	12,789

River Regimes:

The pattern of flow of water in a river channel over a year is known as its **regime**.

Himalayan river:

- The **north Indian** rivers originating from the Himalayas are **perennial** as they are **fed by glaciers** through snow melt and also **receive rainfall water** during rainy season so there is **less fluctuations** in river regime.
- The **rivers of South India do not originate from glaciers** and their flow **pattern witnesses fluctuations**. Thus, the regime of the rivers of South India is **controlled by rainfall** which also varies from one part of the Peninsular plateau to the other.

Discharge: The discharge is the **volume of water** flowing in a river and it is measured either in cusecs (cubic feet per second) or cumecs (cubic metres per second).

Ganga: It has its minimum flow during the January-June period. The maximum flow is attained either in August or in September. After September, there is a steady fall in the flow. The river, thus, has a **monsoon regime during the rainy season**.

- There are striking differences in the river regimes in the eastern and the western parts of the Ganga Basin.
  - The Ganga maintains a sizeable flow in the early part of summer due to

snow melt before the monsoon rains begin.

- The mean maximum discharge of the Ganga at Farakka is about 55,000 cusecs while the mean minimum is only 1,300 cusecs.

Peninsular rivers

Narmada:

- It has a very low volume of discharge from January to July, but it suddenly rises in August when the maximum flow is attained.
- The fall in October is as spectacular as the rise in August.
- The flow of water in the Narmada, as recorded at Garudeshwar, shows that the maximum flow is of the order of 2,300 cusecs, while the minimum flow is only 15 cusecs.

Godavari:

- It has the minimum discharge in May, and the maximum in July-August.
- After August, there is a sharp fall in water flow although the volume of flow in October and November is higher than that in any of the months from January to May.
- The mean maximum discharge of the Godavari at Polavaram is 3,200 cusecs while the mean minimum flow is only 50 cusecs.

Table 3.1: comparison between Himalayan and peninsular river system.

Aspects	Himalayan river	Peninsular river
Place of origin	Mountains covered with **glaciers**	Peninsular plateau and central **highland**
Nature of flow	**Perennial**: Receive water from **glaciers and rainfall**	**Seasonal**: Dependent on **monsoon** rainfall
Type of drainage	**Antecedent and consequent** leading to **dendritic** pattern in plains	**Super imposed**, rejuvenated resulting in **trellis, radial and rectangular** pattern
Nature of river	**Long course**, flowing through the rigged mountains experiencing headward **erosion and river capturing.** In plains, **meandering and shifting of course**	**Smaller, fixed** course and **well-adjusted valleys**

Catchment area	Very **large** basin	Relatively **smaller** basin
Age of river	**Young** and youthful, active, and deepening in river valleys	**Old** rivers with graded profile and have almost reached their base level

Uneven Distribution of Water:

The rivers of India carry huge volumes of water per year, but it is unevenly distributed both in time and space.

- There are **perennial rivers** carrying water **throughout the year** while the **non-perennial rivers** have very little water **during monsoon**.
- During rainy season much of water of the **water is wasted** in floods and flows down to the sea.
- When there is a flood in one part of the country, the other area suffers from drought.

Reasons of River pollution:

- **Industrial affluents** and wastes get disposed in rivers.
- Most of the **cremation grounds** are on the banks of rivers and the dead bodies are sometimes thrown in the rivers.
- On the occasion of some **festivals**, the flowers and statues are immersed in the rivers.
- Large scale b**athing and washing** of clothes.

Interesting Points:

- **Important Drainage Patters:**
  - **Dendritic**: The drainage pattern resembling the **branches of a tree** is known as "dendritic" such as the rivers of northern plain.
  - **Radial:** When the rivers originate from a hill and flow in all directions, the drainage pattern is known as 'radial' such as the rivers originating from the **Amarkantak range**.
  - **Trellis:** When the primary tributaries of **rivers flow parallel to each other** and **secondary tributaries join them at right angles**, the pattern is known as 'trellis'.
  - **Centripetal:** When the rivers discharge their waters **from all directions** in a lake or depression, the pattern is known as 'centripetal'.
- **'Namami Gange Programme:** It is an Integrated flagship Conservation programme approved in June 2014 with the **twin objectives** of effective abatement of pollution, conservation and rejuvenation of the National River Ganga. **Main pillars** of the Namami Gange Programme are:
  - Sewerage Treatment Infrastructure
  - River-Front Development
  - River-Surface Cleaning
  - Biodiversity
  - Afforestation
  - Public Awareness
  - Industrial Effluent Monitoring
  - Ganga Gram

Unit: III

Climate, Vegetation and Soil

4 Climate

Climate refers to the **average of the weather conditions** over a longer period of time. India has hot monsoonal climate which is the prevalent climate in south and southeast Asia.

Climate of India:

- Monsoon connotes the climate associated with **seasonal reversal** in the direction of winds.
- The climate of India has many regional variations expressed in the pattern of winds, temperature and rainfall, rhythm of seasons and the degree of wetness or dryness. These regional diversities may be described as **sub-types of monsoon climate**.

Regional Variations in Precipitation:

- While snowfall occurs in the Himalayas, it only rains over the rest of the country.
- **Cherrapunji and Mawsynram** in the Khasi Hills of Meghalaya receive rainfall over 1,080 cm in a year whereas Jaisalmer in Rajasthan rarely gets more than 9 cm of rainfall during the same period.
- The **Ganga delta and the coastal plains** of Odisha are hit by strong **rain-bearing storms** in July and August.
- The **Coromandal coast goes generally dry** during July and August months.
- Most parts of India get rainfall during June-September, but **on the coastal areas of Tamil Nadu, it rains in the beginning of the winter season.**

Factors Determining Climate of India:

India's climate is controlled by a number of factors which can be broadly divided into two groups — factors related to location and relief, and factors related to air pressure and winds.

Factors related to Location and Relief

Latitude:

- The Tropic of Cancer passes through the central part of India in east-west direction. Thus, **northern part** of the India lies in **sub-tropical and temperate zone** and the part lying **south** of the Tropic of Cancer falls in the **tropical zone**.
- The tropical zone being nearer to the equator, experiences **high temperatures** throughout the year with small daily and annual range.
- Area north of the Tropic of Cancer being away from the equator, experiences extreme **climate with high daily and annual range of temperature**.

Himalayan Mountains:

- It acts as an effective **climatic divide** and protects the subcontinent from the cold northern winds. These cold and chilly winds originate near the Arctic circle and blow across central and eastern Asia.
- The Himalayas also trap the **monsoon winds**, forcing them to **shed their moisture** within the subcontinent.

Distribution of Land and Water:

- India is flanked by the Indian Ocean on three sides in the south and girdled by a high and continuous mountain-wall in the north.
- As compared to the landmass, **water heats up or cools down slowly**. This **differential heating of land and sea** creates different air pressure zones in

different seasons in and around the Indian subcontinent.

- **Difference in air pressure** causes **reversal in the direction** of monsoon winds.

Distance from the Sea:

- With a long coastline, large **coastal areas have an equable climate**.
- Areas in the **interior of India** are far away from the **moderating influence of the sea**. Such areas have extremes of climate.
- The seasonal contrasts in weather at places in the interior of the country such as Delhi, Kanpur and Amritsar can be observed.

Altitude:

- Temperature **decreases with height**.
- Due to thin air, places in the mountains are cooler than places on the plains. For example, Agra and Darjiling are located on the same latitude, but temperature of January in Agra is 16°C whereas it is only 4°C in Darjiling.

Relief:

- The physiography or relief of India also affects the temperature, air pressure, direction and speed of wind and the amount and distribution of rainfall.
- The **windward sides of Western Ghats and Assam receive high rainfall** during June-September whereas the **southern plateau remains dry due to its leeward situation along the Western Ghats.**

Air Pressure and Wind: To understand the differences in local climates of India, it is necessary to understand the mechanism of the following three factors:

- **Distribution of air pressure and winds** on the surface of the earth.
- **Upper air circulation** caused by factors controlling global weather and the inflow of different **air masses and jet streams**.
- Inflow of **western cyclones** generally known as **disturbances** during the winter season and tropical depressions during the south-west monsoon period into India, creating weather conditions favourable to rainfall.

Mechanism of Weather in the Winter Season

Surface Pressure and Winds:

- In winter months, the weather conditions over India are generally influenced by the distribution of pressure in Central and Western Asia.
- A **high-pressure centre** in the region lying to the north of the Himalayas **develops during winter.**
- The centre of **high pressure** gives rise to the **flow of air at the low level** from the north towards the Indian subcontinent, south of the mountain range.
- The **surface winds** blowing out of the high-pressure centre over Central Asia reach India in the form of a dry continental air mass.
    - These continental winds encounter trade winds over north-western India.
    - The position of this contact zone is not, however, stable.
- Occasionally, it may **shift its position** as far east as the middle Ganga valley with the result that the whole of the north-western and northern India up to the middle Ganga valley comes under the **influence of dry north-western winds**.

Jet Stream and Upper Air Circulation:

- Jet streams are observed up in the **lower troposphere**, about 3 km above the surface of the earth.
- The variations in the atmospheric pressure closer to the surface of the earth have no role to play in the making of upper air circulation.
- All of Western and Central Asia remains under the influence of **westerly winds** along the altitude of 9-13 km from west to east.
- These winds blow across the Asian continent at latitudes north of the Himalayas roughly parallel to the Tibetan highlands and are known as **jet streams**.
- **Tibetan highlands** act as a **barrier** in the path of these jet streams. As a result, **jet streams get bifurcated**
    - One of its branches blows to the north of the Tibetan highlands.
    - The southern branch blows in an eastward direction, south of the Himalayas.
        - It has its mean position at 25°N in February at 200-300 mb level.
        - It is believed that this **southern branch of the jet stream exercises an important influence** on the winter weather in India.

Western Cyclonic Disturbance and Tropical Cyclones:

- The **western cyclonic disturbances** which enter the Indian subcontinent from the west and the northwest during the winter months, **originate over the**

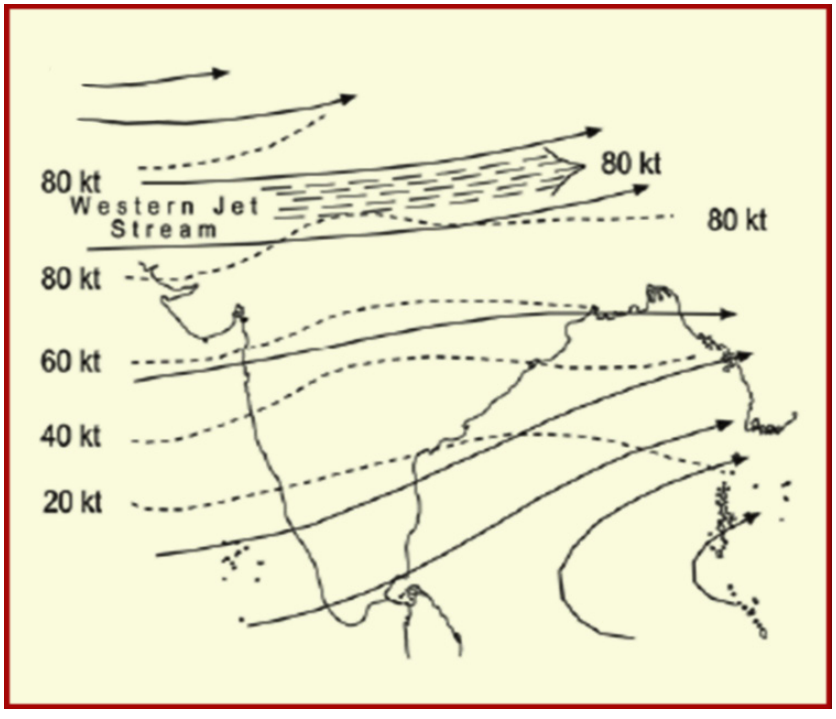

Fig. 4.1: Direction of Winds in India in Winter at the Height of 9-13 km

Mediterranean Sea and are brought into India by the **westerly jet stream**.

- An increase in the prevailing night temperature generally indicates an advance in the arrival of these cyclones' disturbances.
- **Tropical cyclones** originate over the Bay of Bengal and the Indian ocean. These tropical cyclones have very high wind velocity and heavy rainfall and **hit the Tamil Nadu, Andhra Pradesh and Odisha coast.**
- Most of these cyclones are **very destructive** due to **high wind velocity and torrential rain** that accompanies it.

Mechanism of Weather in Summer Season

Surface Pressure and Winds:

- When the **sun shifts northwards**, the wind circulation over the subcontinent undergoes a **complete reversal** at both, the lower and the upper levels.
- By the middle of July, the **low-pressure belt** nearer the surface [termed as **Inter Tropical Convergence Zone (ITCZ)**] shifts northwards, roughly parallel to the Himalayas between 20° N and 25° N.
- By this time, the **westerly jet stream withdraws** from the Indian region.
- There is an **interrelationship** between the **northward shift** of the equatorial trough (ITCZ) and the **withdrawal of the westerly jet stream** from over the North Indian Plain.
- **ITCZ** is **low pressure zone** and **attract maritime tropical airmass** from the southern hemisphere, after crossing the equator, rushes to the low-pressure area in the general south-westerly direction.
- It is this moist air current which is popularly known as the **southwest monsoon**.

Jet Streams and Upper Air Circulation:

- The pattern of pressure and winds is formed only at the level of the troposphere.
- An **easterly jet stream** flows over the southern part of the Peninsula in June.
- In August, it is confined to 15°N latitude, and in September up to 22° N latitudes.
- The **easterlies** normally do not extend to the north of 30° N latitude in the upper atmosphere.

Easterly Jet Stream and Tropical Cyclones:

- The easterly jet stream **steers the tropical depressions** into India.
- These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent.
- The tracks of these depressions are the **areas of highest rainfall** in India.

The frequency at which these depressions visit India, their direction and intensity, all go a long way in **determining the rainfall pattern during the southwest monsoon** period.

The Nature of Indian Monsoon:

Systematic studies of the causes of rainfall in the South Asian region help to understand the causes and salient features of the monsoon, particularly some of its important aspects, such as:

- The onset of the monsoon.
- Rain-bearing systems (e.g., tropical cyclones) and the relationship between

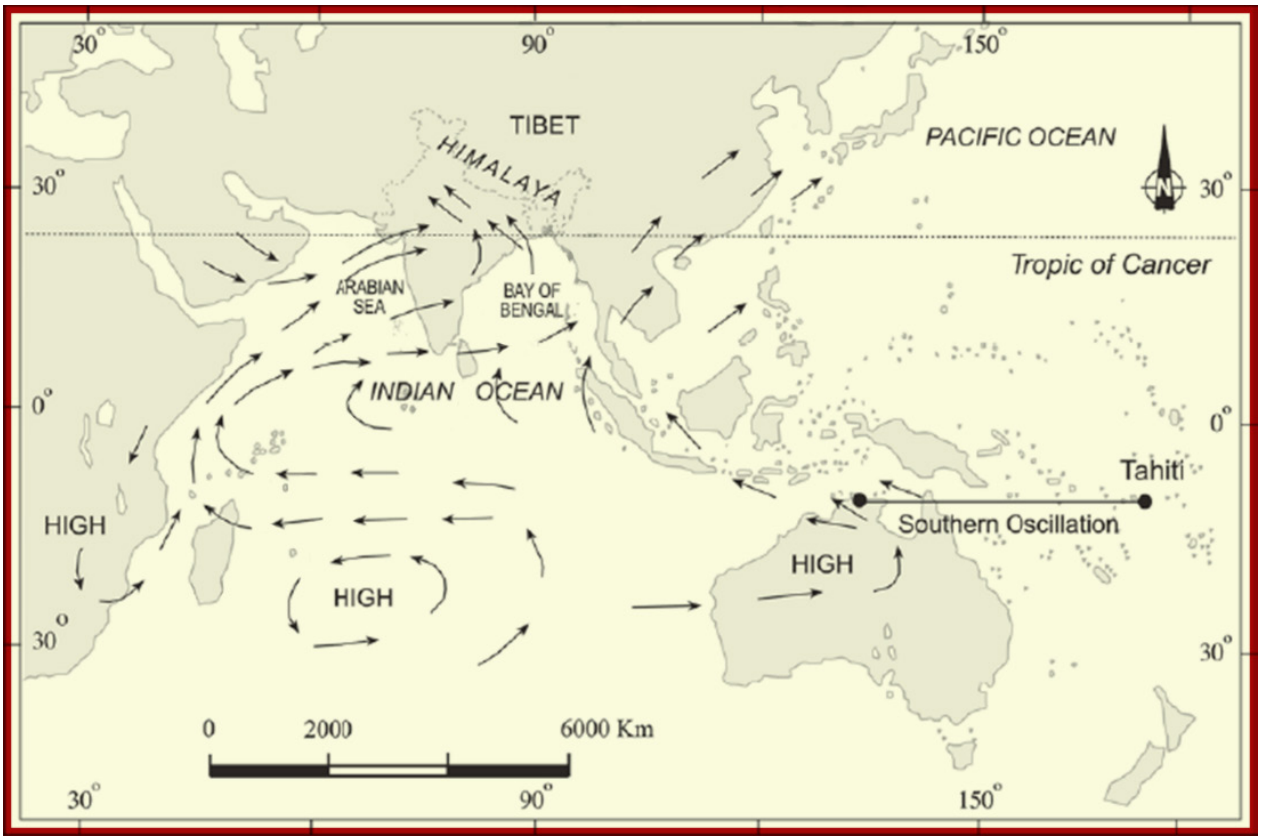

Figure 4.2: Summer Monsoon Winds (Surface Circulation)

their frequency and distribution of monsoon rainfall.

- Break in the monsoon

Onset of the Monsoon:

- It was believed that the **differential heating of land and sea** during the summer months is the mechanism which **sets the stage for the monsoon winds** to drift towards the subcontinent.
- During April and May when the sun shines vertically over the Tropic of Cancer, the large landmass in the north of Indian ocean gets **intensely heated**.
- This causes the formation of an **intense low pressure** in the north-western part of the subcontinent. Since the pressure in the Indian Ocean in the south of the landmass is high as water gets heat slowly and **low-pressure cell attracts southeast trades** across the Equator.
- The **southwest monsoon** may be seen as a continuation of the **southeast trades deflected towards the Indian subcontinent** after crossing the Equator.
- These winds **cross the Equator between 40°E and 60°E longitudes**.
- The **shift in position to ITCZ** is also related to the phenomenon of the **withdrawal of the westerly jet stream** from its position over the north Indian plain, south Himalayas.

- The **easterly jet stream** sets in along 15°N latitude **only after the western jet stream** has withdrawn itself from the region. This **easterly jet stream** is held responsible for the **burst of the monsoon** in India.
- **Entry of Monsoon into India:** The southwest monsoon sets in over the **Kerala coast by 1st June** and moves swiftly to reach Mumbai and Kolkata between 10th and 13th June. By mid-July southwest monsoon engulfs the entire subcontinent.

Rain-bearing Systems and Rainfall Distribution:

- **Two rain-bearing systems** in India.
  - First originate in the **Bay of Bengal** causing rainfall over the plains of north India.
  - Second is the **Arabian Sea current** of the southwest monsoon which brings rain to the west coast of India.
- Much of the **rainfall along the Western Ghats** is **orographic** as the moist air is obstructed and forced to rise **along the Ghats**.
- The **intensity of rainfall** over the west coast of India is related to **two factors**:
  - The offshore meteorological conditions.
  - The position of the equatorial jet stream along the eastern coast of Africa.
- The frequency of the tropical depressions originating from the Bay of Bengal varies from year to year.
  - Their paths over India are mainly determined by the position of ITCZ which is generally termed as the **monsoon trough**.
  - As the axis of the monsoon trough oscillates, there are fluctuations in the track and direction of these depressions, and the intensity and the amount of rainfall vary from year to year.
- The rain which comes in spells, displays a **declining trend from west to east over the west coast**, and from the **southeast towards the northwest over the North Indian Plain and the northern part of the Peninsula**.

Break in the Monsoon:

- During the **south-west monsoon** period after having rains for a few days, if **rain fails to occur** for one or more weeks, it is known as **break in the monsoon**.
- These **dry spells** are quite common during the rainy season.
- These breaks in the different regions are due to different reasons:
  - **In northern India** rains are likely to fail if the **rain-bearing storms are not very frequent** along the monsoon trough or the ITCZ over this region.
  - **Over the west coast** the dry spells are associated with days when **winds blow parallel to the coast.**

The Rhythm of Seasons:

The **climatic conditions of India** can best be described in terms of an **annual cycle of seasons**. The meteorologists recognise the following **four seasons**:

- Cold weather season
- Hot weather season
- Southwest monsoon season
- Retreating monsoon season

Cold Weather Season

Temperature:

- Usually, the cold weather season **sets in by mid-November** in northern India.
- December and January are the **coldest months** in the northern plain.
- The **mean daily temperature** remains below 21°C, over most parts of northern India.
- The **night temperature** may be quite low.
- There are **three main reasons for the excessive cold** in north India during this season:
  - States like Punjab, Haryana and Rajasthan being far **away from the moderating influence of sea** experience continental climate.
  - The **snowfall** in the nearby Himalayan ranges creates cold wave situation.
  - Around February, the **cold winds coming from the Caspian Sea and Turkmenistan** bring cold wave along with frost and fog over the north-western parts of India.
- The **Peninsular region** of India, however, does **not have any well-defined cold weather** season.
- There is **hardly any seasonal change** in the distribution pattern of the temperature in **coastal areas** because of moderating influence of the sea and the proximity to equator.

Pressure and Winds:

- By the end of December (22nd December), the **sun shines vertically over the Tropic of Capricorn in the southern hemisphere**.
- The weather in this season is characterised by **feeble high-pressure conditions** over the northern plain. In South India, air pressure slightly lower.
  - As a result, **winds start blowing** from north-western high-pressure zone to the low air pressure zone over the Indian Ocean in the south.
- Due to **low pressure gradient**, the light winds with a low velocity of about 3-5 km per hour begin to blow outwards.
- By and large, the **topography of the region** influences the wind direction.
  - They are westerly or north-westerly down the **Ganga Valley**.
  - They become northerly in the **Ganga-Brahmaputra delta**.
  - Free from the influence of topography, they are clearly north-easterly **over the Bay of Bengal.**
- **Cyclonic depressions** originating over the east Mediterranean Sea and **travelling eastwards across West Asia**, Iran, Afghanistan and Pakistan before they reach the north-western parts of India.
- On their way, the moisture content gets augmented from the Caspian Sea in the north and the Persian Gulf in the south.

Rainfall: Winter monsoons **do not cause rainfall** as they move from land to the sea. It is because they have little humidity and due to anti cyclonic circulation on land, the possibility of rainfall from them reduces. However, there are **some exceptions** to it:

- Some weak **temperate cyclones from the Mediterranean Sea** cause rainfall in Punjab, Haryana, Delhi and western Uttar Pradesh.
  - Although the amount is meagre, it is **highly beneficial for rabi crops**.

- The **precipitation is in the form of snowfall** in the lower Himalayas. It is this snow that sustains the flow of water in the Himalayan rivers during the summer months.

- The precipitation goes on **decreasing from west to east in the plains** and from **north to south in the mountains.**
- Central parts of India and northern parts of southern Peninsula also get **winter rainfall occasionally.**
- Arunachal Pradesh and Assam in the north-eastern parts of India also have rains between 25 mm and 50 mm during these winter months.
- During October and November, **northeast monsoon** while crossing over the Bay of Bengal, picks up moisture and causes torrential rainfall over the **Tamil Nadu coast**, southern Andhra Pradesh, southeast Karnataka and southeast Kerala.

Hot Weather Season

Temperature:

- The **apparent northward movement** of the sun towards the **Tropic of Cancer** in March, temperatures start rising in north India.
- April, May and June are the **months of summer in north India**.
- The **hot weather season** in south India is **mild** and not so intense as found in north India.
- The Peninsular situation of south India with **moderating effect** of the oceans keeps the temperatures lower than that prevailing in north India.
- In the coastal regions, the **north-south extent of isotherms parallel to the coast** confirms that temperature does not decrease from north to south rather it **increases from the coast to the interior.**

Pressure and Winds:

- The summer months are a period of **excessive heat** and **falling air pressure** in the northern half of the country.
- Because of the heating of the subcontinent, this elongated **low pressure monsoon trough** extends over the Thar desert in the north-west to Patna and Chotanagpur plateau in the east-southeast.
- The location of the **ITCZ attracts a surface circulation of the winds** which are south-westerly on the west coast as well as along the coast of West Bengal and Bangladesh.
- Currents of **south-westerly monsoon** are in reality **'displaced' equatorial westerlies**. The influx of these winds by mid-June brings about a change in the weather towards the rainy season.
- In the heart of the ITCZ in the northwest, the dry and hot winds known as '**Loo'**, **blows in the afternoon.**
- **Dust storms** in the evening are very common during May in Punjab, Haryana, Eastern Rajasthan and Uttar Pradesh.
  - These temporary storms bring a welcome respite from the oppressing heat since they bring with them **light rains and a pleasant cool breeze**.

A sudden contact between dry and moist air masses gives rise to **local storms of great intensity**, these local storms are associated with violent winds, torrential rains and hailstorms.

Famous local Storms of Hot Weather Season

- **Mango Shower:** There are **pre-monsoon showers** which are a common phenomenon in **Kerala** and **coastal areas of Karnataka**. Locally, they are known as mango showers since they **help in the early ripening of mangoes**.
- **Blossom Shower:** With this shower, **coffee flowers blossom** in **Kerala** and nearby areas.
- **Nor Westers:** These are dreaded evening thunderstorms in **Bengal and Assam**.
  - Their notorious nature can be understood from the local nomenclature of '**Kalbaisakhi'**, a calamity of the month of Baisakh.
  - These showers are useful for **tea, jute and rice** cultivation**.**
  - **In Assam**, these storms are known as **"Bardoli Chheerha".**
- **Loo:** Hot, dry, and oppressing winds blowing in the **Northern plains** from Punjab to Bihar with **higher intensity between Delhi**

South-West Monsoon Season:

- **High temperature over northern plains** create **lower pressure condition**, and they are powerful enough to **attract trade winds of southern hemisphere**.
- These **southeast trade winds cross the equator** and enter the Bay of Bengal and the Arabian Sea.
- Passing over the **equatorial warm currents**, they bring with them moisture in abundance.
- After crossing the equator, they follow a **south-westerly direction**.
- The sudden onset of the moisture-laden winds associated with violent thunder and lightning, is often termed as the **"break" or "burst"** of the monsoons.

Two branches of monsoon :

- **Arabian sea branch:** The monsoon winds originating over the Arabian Sea further **split into three branches**:
  - **First branch**: It is obstructed by the **Western Ghats** and climb the slopes of the Western Ghats from 900-1200 m.
    - The **windward side** of the Sahyadris and Western Coastal Plain receive very **heavy rainfall** ranging between 250 cm and 400 cm.
    - After **crossing western ghats,** these winds descend and become hotter and get heated up and reduces moisture, thus **east of western ghat is the rain shadow region.**
  - **Second branch**: It strikes with **coast of the north Mumbai.**
    - It moves along **valley of Narmada and Tapi** and cause **extensive rainfall over central India**.
    - It **enters the Ganga plains** and **mingle with the Bay of Bengal branch**.
  - **Third branch**: It strikes the **Saurashtra Peninsula and the Kachchh**.

- It then passes over west Rajasthan and along the Aravalis, causing only a **scanty rainfall**.
- In Punjab and Haryana, it too **joins the Bay of Bengal branch**. These two branches, reinforced by each other, cause **rains in the western Himalayas**.

- **Bay of Bengal branch:**
  - It strikes the **coast of Myanmar** and **part of southeast Bangladesh** but **Arakan Hills** along the coast of Myanmar **deflect a big portion** of this branch towards the Indian subcontinent.
  - The monsoon **enters West Bengal and Bangladesh** from south and southeast direction.
  - This branch **splits into two under** the influence of the Himalayas and the thermal low is northwest India.
    - One branch **moves westward along the Ganga plains** reaching as far as the Punjab plains.
    - The other branch **moves up the Brahmaputra valley** in the north and the northeast, causing widespread rains.
      - Its sub-branch **strikes the Garo and Khasi hills** of Meghalaya.
      - **Mawsynram**, located on the crest of **Khasi hills**, receives the **highest average annual rainfall** in the world.
  - **Tamil Nadu coast remains dry** during this season:
    - The Tamil Nadu coast is situated **parallel to the Bay of Bengal branch** of southwest monsoon.
    - It **lies in the rain-shadow area** of the Arabian Sea branch of the south-west monsoon.

Characteristics of Monsoon Rainfall:

- Rainfall received from the southwest monsoons is **seasonal** in character, which occurs between June and September.
- Monsoonal rainfall is **largely governed by relief or topography**.
  - For instance, the windward side of the Western Ghats register a rainfall of over 250 cm.
  - The heavy rainfall in the north-eastern states can be attributed to their hill ranges and the Eastern Himalayas.
- The monsoon **rainfall has a declining trend with increasing distance from the sea.** Kolkata receives 119 cm during the southwest monsoon period, Patna 105 cm, Allahabad 76 cm and Delhi 56 cm.
- The monsoon **rains occur in wet spells of few days'** duration at a time.
  - The wet spells are interspersed with **rainless interval** known as **'breaks**.
  - These breaks in rainfall are related to the **cyclonic depressions** mainly formed at the head of the Bay of Bengal, and their crossing into the mainland.
- Besides the frequency and intensity of these depressions, the passage followed by them determines the **spatial distribution of rainfall**.

- The summer rainfall comes in a **heavy downpour** leading to considerable run off and soil erosion.
- Monsoons play a pivotal role in the **agrarian economy of India** because over **three-fourths of the total rain in the country is received during the southwest monsoon** season.
- Its **spatial distribution is also uneven** which ranges from 12 cm to more than 250 cm.
- The beginning of the rains sometimes is considerably delayed over the whole or a part of the country.
- The rains sometimes end considerably earlier than usual, causing great damage to standing crops and making the sowing of winter crops difficult.

Season of Retreating Monsoon:

- The months of **October and November** are known for **retreating monsoons**.
- By the end of September, the southwest monsoon becomes weak as the **low-pressure trough** of the Ganga plain starts moving southward in response to the southward march of the sun.
- The monsoon **retreats from the western Rajasthan** by the first week of September.
- It withdraws from Rajasthan, Gujarat, Western Ganga plain and the Central Highlands by the end of the month.
- By the beginning of October, the low pressure covers northern parts of the Bay of Bengal and by early November, it moves over Karnataka and Tamil Nadu.
- By the **middle of December**, the centre of **low pressure is completely removed from the Peninsula.**
- It is marked by **clear skies and rise in temperature**. The **land is still moist**.
- Owing to the conditions of **high temperature and humidity**, the weather becomes rather oppressive. This is commonly known as the **'October heat'**.
- In the second half of October, the mercury begins to fall rapidly, particularly in northern India.
- The weather in the retreating monsoon is dry in north India but it is associated with rain in the **eastern part of the Peninsula**.
- The widespread rain in this season is associated with the **passage of cyclonic depressions** which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula.
    - These tropical cyclones are very destructive.
    - The thickly populated deltas of the Godavari, Krishna and Kaveri are their preferred targets.
    - A few cyclonic storms also strike the coast of West Bengal, Bangladesh and Myanmar.
    - The bulk of the rainfall of the **Coromandal coast** is derived from these **depressions and cyclones.**
    - Such cyclonic storms are less frequent in the Arabian Sea.

El-Nino and Indian Monsoon

EI-Nino is a complex weather system that appears **once every three to seven years**, bringing **drought, floods and other weather extremes** to different parts of the world.

- The system involves oceanic and atmospheric phenomena with the **appearance of warm currents** off the coast of Peru in the Eastern Pacific and affects weather in many places including India.
- EI-Nino is merely an **extension of the warm equatorial current** which gets replaced temporarily by cold Peruvian current or Humboldt current.
- This current increases the temperature of water on the Peruvian coast by 10°C and results in:
  - The **distortion** of **equatorial atmospheric circulation**.
  - **Irregularities** in the **evaporation of sea water**.
  - **Reduction** in the number of **planktons** which further reduces the **number of fish** in the sea.
- EI-Nino is used in India for **forecasting long range monsoon rainfall**.

Traditional Indian Seasons:

- In the Indian tradition, **a year is divided into six two-monthly seasons**. This cycle of seasons, which the common people in north and central India followed.
- However, this system **does not match** with the seasons of **south India** where there is little variation in the seasons.

Table 4.1: Name of seasons in Traditional Indian and Gregorian calendar

Seasons	Months (according to Indian tradition)	Months (according to Gregorian calendar)
Vasanta	Chaitra-Vaisakha	March-April
Grishma	Jiashtha-Asadha	May-June
Varsha	Sravana-Bhadra	July-August
Sharada	Asvina-Kartika	September-October
Hemanta	Margashirsha-Pusha	November-December
Shishira	Magha-Phalguna	January-February

Distribution of Rainfall:

The **average annual rainfall in India is about 125 cm**, but it has great spatial variations.

- **Areas of High Rainfall:**
  - The highest rainfall occurs on the **Western Ghats**, as well as in the **sub-Himalayan areas** (northeast and the hills of Meghalaya).
  - In some parts of **Khasi and Jaintia hills**, the rainfall **exceeds 1,000 cm.**
  - In the **Brahmaputra valley** and the adjoining hills, the rainfall is less than 200 cm.
- **Areas of Medium Rainfall**:
  - Rainfall **between 100-200 cm** is received in the southern parts of Gujarat, east Tamil Nadu, north-eastern Peninsula covering Odisha, Jharkhand, Bihar, eastern Madhya Pradesh, northern Ganga plain along the sub-Himalayas and the Cachar Valley and Manipur.
- **Areas of Low Rainfall:** Western Uttar Pradesh, Delhi, Haryana, Punjab, Jammu and Kashmir, eastern Rajasthan, Gujarat and Deccan Plateau receive rainfall **between 50-100 cm.**
- **Areas of Inadequate Rainfall:** Parts of the Peninsula, especially in Andhra Pradesh, Karnataka and Maharashtra, Ladakh and most of western Rajasthan receive rainfall **below 50 cm.**
- **Snowfall is restricted to Himalayan region.**

Variability of Rainfall:

- A characteristic feature of rainfall in India is its variability. The variability of rainfall is computed with the help of the following formula:

$$\text{C.V.} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

Here, C.V. is the coefficient of variation.

- The values of coefficient of variation show the **change from the mean values of rainfall**. The actual rainfall in some places **deviates from 20-50 per cent**.
- A variability of **less than 25 per cent** exists on the western coasts, Western Ghats, north-eastern Peninsula, eastern plains of the Ganga, north-eastern India, Uttarakhand and Himachal Pradesh and south-western part of Jammu and Kashmir. These areas have an **annual rainfall of over 100 cm.**
- A variability of **over 50 per cent** exists in the western part of Rajasthan, northern part of Jammu and Kashmir and interior parts of the Deccan plateau. These areas have an **annual rainfall of less than 50 cm.**
- Rest of India have a variability of **25-50 per cent** and these areas receive an **annual rainfall between 50 -100 cm.**

Climatic Regions of India:

- A climatic region has a **homogeneous** climatic condition which is the result of a combination of factors.
- **Temperature and rainfall** are two important elements which are considered to be decisive in all the schemes of climatic classification.
- **Koeppen** based his scheme of Climatic classification on monthly values of temperature and precipitation. He identified **five major climatic types, namely**:
  - **Tropical climates**: Mean monthly temperature throughout the year is over 18°C.

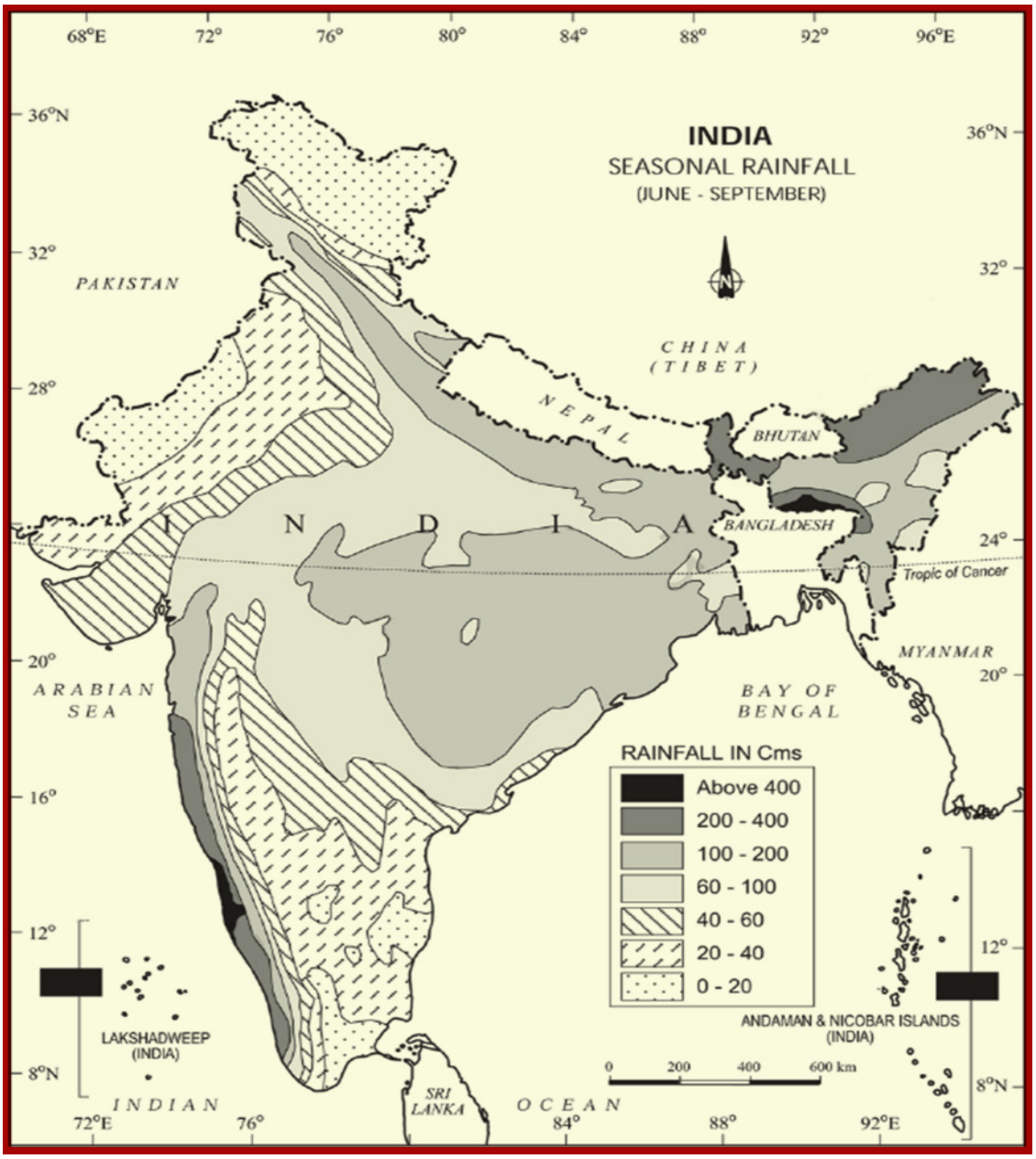

Figure 4.3: India: Seasonal Rainfall (June-September)

- **Dry climates**: Precipitation is very low in comparison to temperature, and hence, dry. If dryness is less, it is semiarid (S); if it is more, the climate is arid(W).
- **Warm temperate climates**: Mean temperature of the coldest month is between 18°C and minus 3°C.
- **Cool temperate climates**: Mean temperature of the warmest month

is over 10°C, and mean temperature of the coldest month is under minus 3°C.
    - **Ice climates**: Mean temperature of the warmest month is under 10°C.
- Koeppen used letter symbols to denote climatic types as given above.
- Each type is further sub-divided into sub-types on the basis of seasonal variations in the distributional pattern of rainfall and temperature.
- He used **S** for **semi-arid** and **W** for **arid** and the following small letters to define sub-types: **f** (sufficient precipitation), **m** (rain forest despite a dry monsoon season), **w** (dry season in winter), **h** (dry and hot), **c** (less than four months with mean temperature over 10°C), and **g** (Gangetic plain).
- Accordingly, India can be divided into following **eight climatic regions**.

Table 4.2: Climatic Regions of India According to Koeppen's Scheme.

Type of climate	Areas
Amw: Monsoon with short dry season	West coast of India south of Goa
As: Monsoon with dry summer	Coromandal coast of Tamil Nadu
Aw: Tropical savannah	Most of peninsular plateau and south of tropic of cancer
Bwhw: Semiarid steppe climate	North-western Gujarat, some parts of western Rajasthan and Punjab
Bwhw: Hot desert	Extreme western Rajasthan
Cwg: Monsoon with dry winter	Ganga plain, eastern Rajasthan, northern Madhya Pradesh, most of North-east India
Dfc: Cold humid winter with short summer	Arunachal Pradesh
E: Polar type	Jammu and Kashmir, Himachal Pradesh and Uttarakhand

Fig. 4.4: India: Climatic Regions According to Koeppen's Scheme

Monsoon and Economic life of India:

- Monsoon is that axis around which **revolves the entire agricultural cycle** of India. It is because about **64 per cent people of India depend on agriculture** for their livelihood and agriculture itself is based on **southwest monsoon**.
- **Except Himalayas**, all the parts of India have **temperature above the threshold level to grow the crops or plants** throughout the year.
- **Regional variations** in monsoon climate **help in growing various types of crops**.
- Variability of rainfall brings **droughts or floods** every year in some parts of the country.
- Agricultural prosperity of India depends very much on timely and adequately distributed rainfall. If it fails, agriculture is adversely affected particularly in those regions where means of irrigation are not developed.
- **Sudden monsoon burst** creates problem of **soil erosion** over large areas in India.
- **Winter rainfall** by **temperate cyclones** in north India is **highly beneficial for rabi crops**.

Global Warming:

- **Human activities** such as large-scale **industrialisation** and presence of polluting gas in the atmosphere are also important factors responsible for global warming.
- **Carbon dioxide** produced by human activities is a major source of concern. This gas, released to the atmosphere in large quantities by **burning of fossil fuel**, is increasing gradually.
- Other gases like **methane, chlorofluorocarbons, and nitrous oxide** which are present in much smaller concentrations in the atmosphere, together with carbon dioxide are known as **greenhouse gases**. These gases are better **absorbers of long wave radiations** than carbon dioxide, and so, are more effective at **enhancing the greenhouse effect.**

Effect of Global Warming:

It is projected that **by the year 2,100, global temperature will increase by about 2°C**. This rise in temperature will cause many other changes:

- **Rise in sea level**, as a result of melting of glaciers and sea-ice due to warming.
  - On an average, the sea level will **rise 48 cm** by the **end of twenty first century**.
  - This would increase the incidence of **annual flooding**.
- Climatic change would promote **insect borne diseases** like malaria, and lead to shift in climatic boundaries, making some regions wetter and others drier.
- **Agricultural pattern would shift** and human population as well as the ecosystem would experience change.

Interesting Points:

- **Inter Tropical Convergence Zone (ITCZ):**
  - It is a **low-pressure zone** located at the **equator** where trade winds converge, and so, it is a zone where air tends to ascend.
  - In July, the ITCZ is located around 20°N-25°N latitudes (over the Gangetic plain), sometimes called the **monsoon trough**. This monsoon trough encourages the development

of thermal low over north and northwest India.
    - Due to the **shift of ITCZ**, the trade winds of the southern hemisphere cross the equator between 40° and 60°E longitudes and start blowing from southwest to northeast due to the Coriolis force.
- The intensity of southwest monsoon winds of **southern oscillation** can be measured by the difference in **pressure between Tahiti** (roughly 20°S and 140°W) in French Polynesia in East Pacific **and port Darwin** (12°30'S and 131°E) in northern Australia.
- **Indian Meteorological Department (IMD)** can forecast the possible behaviour of monsoons on the basis of **16 indicators.**

5 Natural Vegetation

Natural vegetation refers to a plant community that has been left undisturbed over a long time, so as to allow its individual species to adjust themselves to climate and soil conditions as fully as possible.

Variation in Natural Vegetation of India:

India is a land of great variety of natural vegetation depending upon the variations in the climate and the soil.

- **Himalayan heights** are marked with temperate vegetation.
- **Western Ghats** and the Andaman Nicobar Islands have tropical rain forests.
- **Deltaic regions** have tropical forests and mangroves.
- D**esert and semi-desert** areas of Rajasthan are known for cacti, a wide variety of bushes and thorny vegetation.

Classification of Forests:

On the basis of certain common features such as predominant vegetation type and climatic regions, Indian forests can be divided into the following groups:

- Tropical Evergreen and Semi Evergreen forests.
- Tropical Deciduous forests.
- Tropical Thorn forests.
- Montane forests.
- Littoral and Swamp forests.

Tropical Evergreen Forest:

- **Regions:** These forests are found in the **western slope of the Western Ghats**, **hills of the north-eastern region** and **the Andaman and Nicobar Islands**.
- **Climatic Conditions:** They are found in **warm and humid areas** with an **annual precipitation of over 200 cm** and **mean annual temperature above 22°C.**
- These are **well stratified**, with layers closer to the ground and are covered with shrubs and creepers, with short, structured trees followed by tall variety of trees.
- In these forests, **trees** reach great **heights up to 60 m or above**.
- There is **no definite time** for trees to **shed their leaves**, flowering and fruition. As such these forests **appear green all the year round**.
- **Tree Species:** Rosewood, mahogany, aini, ebony, etc.

Tropical Semi Evergreen Forest:

- **Regions:** These forests are found in the **less rainy parts of evergreen regions**.
- These have a **mixture of evergreen and moist deciduous trees**. The undergrowing climbers provide an evergreen character to these forests.
- **Tree Species**: White cedar, hollock and kail etc.
- The British were aware of the economic value of the forests in India; hence, large scale exploitation of these forests was started.
  - The **oak forests** in Garhwal and Kumaon were **replaced by pine (chirs)** which was needed to lay railway lines.
  - Forests were also cleared for introducing **plantations** of tea, rubber and coffee.
  - The British also used timber for **construction activities** as it acts as an insulator of heat.
  - The protectional use of forests was, thus, replaced by commercial use.

Tropical deciduous forest:

These are the **most widespread forests** in India and are also called the **monsoon forests**. They spread over regions which receive **rainfall between 70-200 cm**. On the basis of the availability of water, these forests are further **divided into moist and dry deciduous**.

- **The Moist deciduous forests:**
  - These are more pronounced in the regions which record **rainfall between 100-200 cm.**
  - These forests are found in the **north-eastern states** along the foothills of Himalayas, **eastern slopes of the Western Ghats and Odisha**.
  - **Tree Species**: Teak, sal, shisham, hurra, mahua, amla, semul, Kusum, and sandalwood.
- **Dry deciduous forest:**
  - These forest **covers vast areas of the country**, where rainfall ranges between **70 -100 cm.**
  - On the wetter margins, it has a **transition** to the moist deciduous, while on the drier margins to thorn forests.
  - These forests are found in rainier areas of **the Peninsula and the plains of Uttar Pradesh and Bihar.**
  - In the higher rainfall regions of the Peninsular plateau and the northern Indian plain, these forests have a **parkland landscape** with open stretches in which **teak and other trees** interspersed with patches of grass are common.
  - **Characteristics:** As the dry season begins, the **trees shed their leaves completely** and the **forest appears like a vast grassland with naked trees** all around.
  - **Tree Species:** Tendu, palas, amaltas, bel, khair, axle wood, etc

Tropical Thorn Forest:

- **Regions:** It grows in areas which receive **rainfall less than 50 cm.**
- It includes **semi-arid areas** of south west Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh.
- In these forests, **plants remain leafless** for most part of the year and give an expression of **scrub vegetation** and it also consists **variety of grasses and shrubs**.
- **Tree Species:** Babool, ber, and wild date palm, khair, neem, khejri, palas.
- **Tussocky grass grows** up to a height of 2 m as the under growth.

Montane Forest:

- In mountainous areas, the **decrease in temperature with increasing altitude** leads to a corresponding change in natural vegetation.
- The Himalayan ranges show a **succession of vegetation** from the tropical to the tundra which change in with the altitude.
- Mountain forests can be **classified into two types** namely the **northern mountain forests and the southern mountain forests.**

Northern Mountain Forest:

- **Deciduous forests** are found in the **foothills** of the **Himalayas**.
- **Wet temperate type** of forests between an **altitude of 1,000-2,000 m.**
  - These trees found in the higher hill ranges of north-eastern India,

hilly areas of West Bengal and Uttaranchal.
    - Evergreen broad leaf trees such as oak and chestnut are predominant.
- **Pine forests** are also well-developed between **1500-1750 m altitude.**
    - **Chir Pine** is very useful commercial tree.
    - **Deodar**, a highly valued endemic species grows mainly in the western part of the Himalayan range. Deodar is a durable wood mainly used in **construction activity**.
    - Similarly, the **chinar and the walnut**, which sustain the famous **Kashmir handicrafts**, belong to this zone.
- **Between heights of 2,225-3048 m:**
    - **Blue pine and spruce** appear.
    - At many places in this zone, **temperate grasslands** are also found.
- **Between 3000-4000 m:**
    - There is a **transition to Alpine forests and pastures**.
    - **Silver firs, junipers, pines, birch and rhododendrons**, etc are found.
    - These pastures are used extensively for transhumance by **tribes like the Gujjars, the Bakarwals, the Bhotia's and the Gaddis**.
- **At higher altitudes, mosses and lichens** form part of the **tundra vegetation**.
- The **southern slopes of the Himalayas** carry a **thicker vegetation** cover because of relatively **higher precipitation** than the drier north-facing slopes.

Southern Mountain Forests:

- It includes the forests found in three distinct areas of Peninsular India viz; the Western Ghats, the Vindhyan and the Nilgiris.
- As they are closer to the tropics, and only 1,500 m above the sea level, vegetation is **temperate in the higher regions**, and **subtropical on the lower regions** of the **Western Ghats**, especially in Kerala, Tamil Nadu and Karnataka.
- The **temperate forests** are called **Sholas** in the Nilgiris, Anaimalai and Palani hills.
- Forest of economic significance include magnolia, laurel, cinchona and wattle.
- Such forests are also found in the Satpura and the Maikal ranges.

Littoral and Swamp Forests:

- India has a rich variety of wetland habitats. About **70 per cent** of this comprises areas under **paddy cultivation**.
- The total area of wet land is 3.9 million hectares.
- Two sites namely **Chilika Lake (Odisha) and Keoladeo National Park (Bharatpur)** are protected as **water-fowl habitats** under the **Convention of Wetlands of International Importance (Ramsar Convention).**
- The country's wetlands have been grouped into **eight categories**,
    - The reservoirs of the **Deccan Plateau** in the south together with the lagoons and other wetlands of the southern west coast.
    - The vast **saline expanses** of Rajasthan, Gujarat and the Gulf of Kachchh.
    - **Freshwater lakes and reservoirs** from Gujarat eastwards through

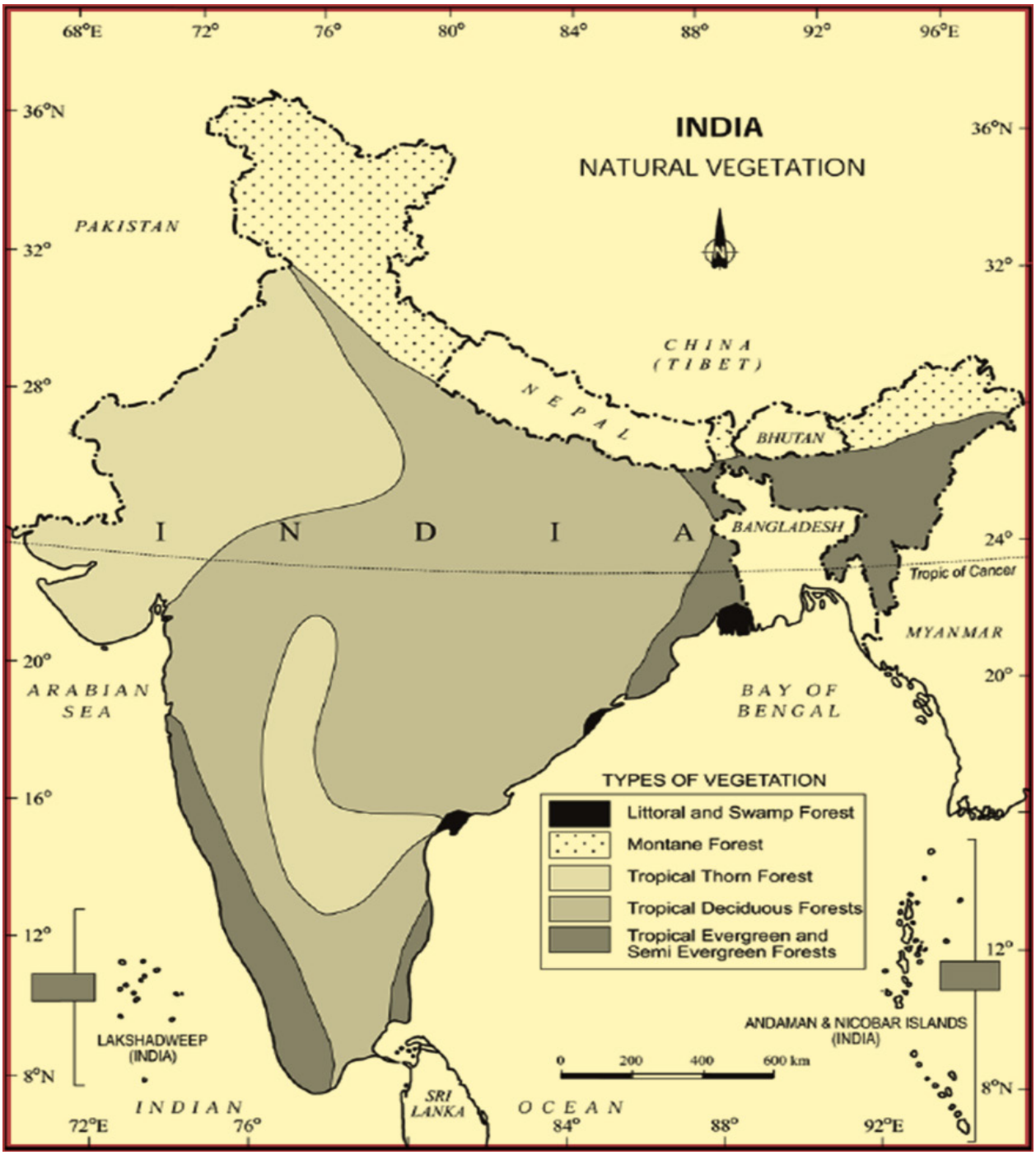

Fig. 5.1: Natural Vegetation

Rajasthan (Keoladeo National Park) and Madhya Pradesh.
- The **delta wetlands and lagoons** of India's east coast (Chilika Lake).
- The freshwater marshes of the **Gangetic Plain**.
- The **floodplains** of the Brahmaputra; the marshes and swamps in the hills of northeast India and the Himalayan foothills.
- The lakes and rivers of the **montane region** of Kashmir and Ladakh.
- The **mangrove forest and other wetlands** of the island arcs of the Andaman and Nicobar Islands.

Mangroves:

- They **grow along the coasts** in the salt marshes, tidal creeks, mud flats and estuaries.
- They consist of several **salt-tolerant species** of plants.
- Crisscrossed by creeks of stagnant water and tidal flows, these forests give shelter to a wide variety of birds.
- They are highly developed in the Andaman and Nicobar Islands and the Sundarbans of West Bengal. Other areas of significance are the Mahanadi, the Godavari and the Krishna deltas.

Forest Cover in India (Updated):

- The forest area is the **area notified and recorded as the forest land** irrespective of the existence of trees. It is **based on the records of the State Revenue Department.**
- The **actual forest cover** is the **area occupied by forests with canopy**. It is **based on aerial photographs and satellite imageries.**
- According to the '**Indian State of The Forest Report 2019'**,
  - Total forest and tree cover rises to **24.56%** of the total geographical area of the country.
  - **Area-wise: Madhya Pradesh has the largest forest cover** in the country followed by Arunachal Pradesh, Chhattisgarh, Odisha, and Maharashtra.
  - In terms of **forest cover as percentage** of total geographical area, the top five States are Mizoram (85.41%), Arunachal Pradesh (79.63%), Meghalaya (76.33%), Manipur (75.46%) and Nagaland (75.31%).
  - **Mangrove cover** has been separately reported in the ISFR 2019 and the total mangrove cover in the country is 4,975 sq. km. An **increase of 54 sq Km** in mangrove cover has been observed.
  - There is **5,188 sq. km increase in total forest cover** as compared to 2017 assessment.
    - **Increase in Forest Cover**: 3,976 sq. km
    - **Increase in Tree Cover:** 12,12 sq.km
  - **The top three states** showing **increase in forest cover** are Karnataka (1,025 sq. km) followed by Andhra Pradesh (990 sq. km) and Kerala (823 sq. km).
  - **Extent of Bamboo:** The extent of bamboo area has estimated at 16 million sq. km. There is **increase of 0.32 million sq. km** as compared to 2017 ISFR report.
  - **Carbon Stock:** In 2019 assessment the total carbon stock in country's

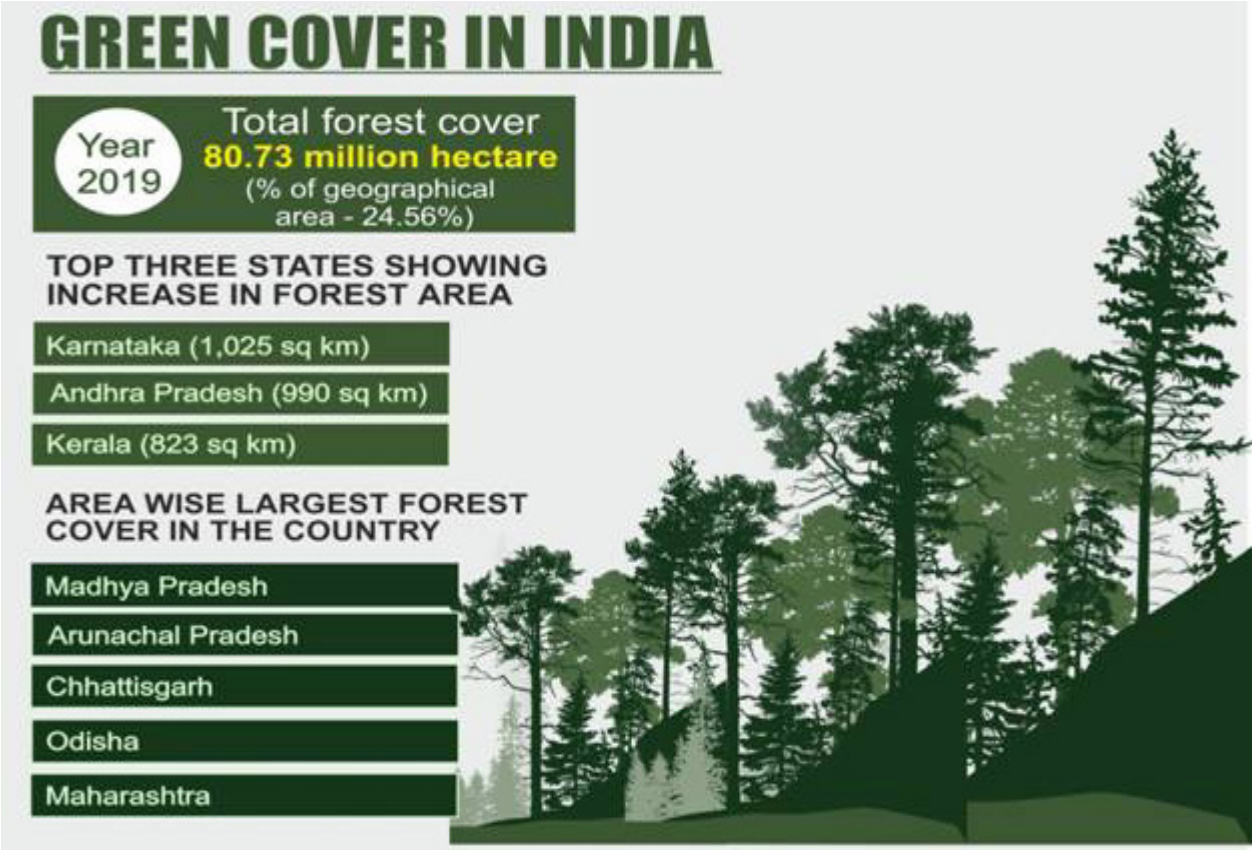

Fig. 5.2: Forest Cover in India

Table 5.1: Percentage cover of the forest

Regions	Percentage cover of the forest
High Concentration	> 40
Medium Concentration	20-40
Low Concentration	10-20

forest is estimated 7,124.6 million tonnes. There is an **increase of 42.6 million tonnes** in the carbon stock of country as compared to the last assessment of 2017.

Forest Conservation:

- Forests have an intricate interrelationship with life and environment. These provide numerous direct and indirect advantages to our economy and society.
- According to **Forest Policy 1988**, the Government will emphasise sustainable forest management in order to conserve and expand forest reserve on the one hand, and to meet the needs of local people on the other. Following are important policy targets,
  - Bringing **33 per cent of the geographical areas under forest cover**.
  - Maintaining **environmental stability** and to restore forests where ***ecological balance*** was disturbed.
  - Conserving the **natural heritage** of the country, its **biological diversity and genetic pool.**
  - Checks **soil erosion**, extension of the desert lands and **reduction of floods and droughts.**
  - Increasing the forest cover through **social forestry** and **afforestation** on degraded land.
  - **Increasing the productivity of forests** to make timber, fuel, fodder and food available to rural population dependant on forests and encourage the substitution of wood.
  - Creating of a massive **people's movement** involving women to encourage planting of trees, stop felling of trees and thus, reduce pressure on the existing forest.

Social forestry

Social forestry means the **management and protection** of **forests and afforestation** on **barren lands** with the purpose of helping in the environmental, social and rural development. The **National Commission on Agriculture (1976)** has classified social forestry into three categories. These are **Urban forestry, Rural forestry and Farm forestry**.

- **Urban Forestry:** It pertains to the **raising and management of trees on public and privately owned lands** in and around urban centres such as green belts, parks, roadside avenues, industrial and commercial green belts, etc.
- **Rural Forestry:** It lays emphasis on **promotion of Agro-forestry and Community forestry**.
  - **Agro-Forestry:** It is the raising of trees and agriculture crops on the same land inclusive of the waste patches. It **combines forestry with agriculture**, thus, altering the simultaneous production of food, fodder, fuel, timber and fruit.

- **Community Forestry:** It involves the **raising of trees on public or community land** such as the village pasture and temple land, roadside, canal bank, strips along railway lines, and schools etc.
  - It aims to provide benefits to the community.
  - People of landless classes can associate with themselves with tree raising.
- **Farm forestry:** It is a term applied to the process under which **farmers grow trees** for **commercial and non-commercial** purposes on their farmlands.
  - **Forest departments** of various states **distribute seedlings of trees** free of cost to small and medium farmers.
  - Several lands such as the margins of agricultural fields, grasslands and pastures, land around homes and cow sheds may be used for raising trees under non-commercial farm forestry.

Wildlife:

It is estimated that about **4-5 per cent of all known plant and animal species** on the earth are **found in India.** There is a considerable threat to the wildlife because of the following reasons:

- **Industrial and technological advancement** brought about a rapid **increase in the exploitation** of forest resources.
- More and more **lands were cleared** for agriculture, human settlement, roads, mining, reservoirs, etc.
- Pressure on forests mounted due to lopping for **fodder and fuelwood** and removal of small timber by the local people.
- **Grazing by domestic cattle** caused an adverse effect on wildlife and its habitat.
- **Hunting** was taken up as a sport by the elite and hundreds of wild animals were killed in a single hunt. Now, **commercial poaching** is rampant.
- Incidence of **forest fire**.

Wildlife Conservation in India:

- In **1972**, a comprehensive **Wildlife Act** was enacted, which provides the main **legal framework** for conservation and protection of wildlife in India. The **two main objectives** of the act are.
  - To provide **protection to the endangered species** listed in the schedule of the Act.
  - To provide **legal support to the conservation areas** of the country classified as National parks, Sanctuaries, and closed areas.
- For the purpose of effective **conservation of flora and fauna**, special steps have been initiated by the Government of India in collaboration with **UNESCO's 'Man and Biosphere Programme'**.
- Following **schemes** have been launched to conserve these species and their habitat in a sustainable manner.
  - **Project Tiger:** The main objective of the scheme is to ensure **maintenance of viable population of tigers** in India for scientific, aesthetic, cultural and

ecological values, and to preserve areas of biological importance as natural heritage for the benefit, education and enjoyment of the people.

- **Project Elephant:** It was launched in **1992** to **assist states having free ranging population of wild elephants**. It was aimed at ensuring long-term survival of identified viable population of elephants in their natural habitat.
- **Crocodile Breeding Project**, **Project Hangul** and conservation of **Himalayan Musk deer** have also been launched by the Government of India.

Biosphere Reserve:

A Biosphere Reserve is a unique and representative ecosystem of terrestrial and coastal areas which are internationally recognised within the **framework of UNESCO's Man and Biosphere (MAB) Programme**. There is total **11 biosphere reserves** are recognised under UNESCO'S MAB programme.

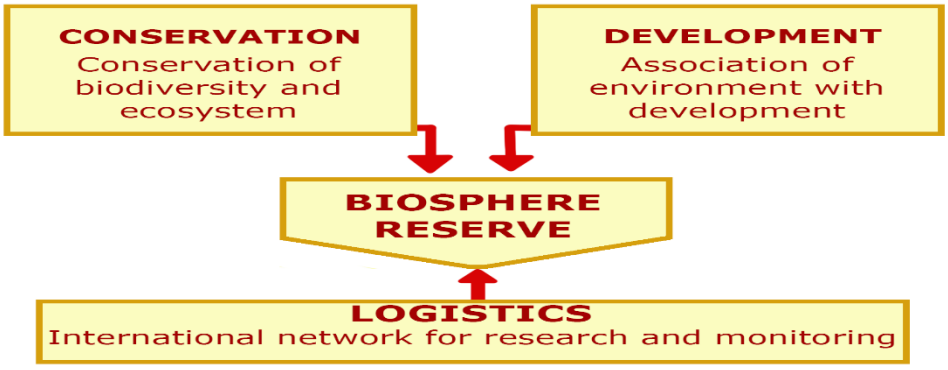

Fig. 5.3: Objectives of a Biosphere Reserve

Nilgiri Biosphere Reserve:

- This is the **first biosphere reserve** was established in September **1986**.
- It embraces the sanctuary complex of **Wayanad, Nagarhole, Bandipore and Mudumalai**, the entire forested hill slopes of **Nilambur, the Upper Nilgiri plateau, Silent Valley and the Siruvani hills.**
- The total area of the biosphere reserve is around 5,520 sq. km.
- It has unspoilt areas of **natural vegetation types** with several dry scrubs, dry and moist deciduous, semievergreen and wet evergreen forests, evergreen sholas, grasslands and swamps.
- It includes the largest known population of **two endangered animal species**, namely the **Nilgiri Tahr** and the **Lion-tailed macaque**.
- The largest south Indian population of elephant, tiger, gaur, sambar and chital as well as a good number of endemic and endangered plants are also found in this reserve.
- Its topography is widely varied.

Nanda Devi Biosphere Reserve:

- It is situated in **Uttarakhand** and includes parts of Chamoli, Almora, Pithoragarh and Bageshwar districts.
- The major forest types of the reserve are **temperate**.
- **Flora**: Silver weed and orchids like latifolie and **rhododendron**.
- **Fauna:** Snow leopard, black bear, brown bear, musk deer, snowcock, golden eagle and black eagle.
- **Major threats**: Collection of endangered plants for medicinal use, forest fires and poaching.

Sundarbans Biosphere Reserve:

- It is located in the **swampy delta** of the river **Ganga in West Bengal**.
- It extends over a vast area of 9,630 sq. km and consists of mangrove forests, swamps and forested islands.
- Sundarbans is the **home of Royal Bengal tigers**. The tigers at the park are good swimmers, and they hunt scarce preys such as chital deer, barking deer, wild pig and even macaques.
- The mangrove forests are characterised by **Heritiera fomes**, a species valued for its **timber**.

Gulf of Mannar Biosphere Reserve:

- The Gulf of Mannar Biosphere Reserve covers an area of 105,000 hectares on the **southeast coast** of India.
- The biosphere reserve **comprises 21 islands** with estuaries, beaches, forests of the nearshore environment, sea grasses, coral reefs, salt marshes and mangroves.
- 3,600 plant and animal species are the globally endangered e.g., **Sea cow** (**Dugong dugon**). Besides six mangrove species, endemic to Peninsular India are also endangered.

Interesting Point:

- Generally, an **international convention** is an agreement among **member states of the United Nations**.

Table 5.2: List of Biosphere Reserves in India

S. No.	Biosphere Reserve and Total Geographical Area (km^2)	Date of Designation	Location in the States/UT
1.	**Nilgiri (5520)**	01.08.1986	Part of Wynad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani Hills (**Tamil Nadu, Kerala, and Karnataka**)
2.	**Nanda Devi (5860.69)**	18.01.1988	Part of Chamoli, Pithoragarh and Almora Districts in **Uttarakhand**

3.	**Nokrek (820)**	01.09.1988	Part of East, West and South Garo Hill Districts in **Meghalaya**
4.	**Manas (2837)**	14.03.1989	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darang Districts in **Assam**
5.	**Sunderban (9630)**	29.03.1989	Part of delta of Ganges and Brahamaputra river system in **West Bengal**
6.	**Gulf of Mannar (10500)**	18.02.1989	Indian part of Gulf of Mannar extending from Rameswaram island in the North to Kaniyakumari in the South of **Tamil Nadu**
7.	**Great Nicobar (885)**	06.01.1989	Southernmost island of **Andaman and Nicobar Islands**
8.	**Similipal (4374)**	21.06.1994	Part of Mayurbhanj District in **Odisha**
9.	**Dibru-Saikhowa (765)**	28.07.1997	Part of Dibrugarh and Tinsukia Districts in **Assam**
10.	**Dehang Debang (5111.5)**	02.09.1998	Part of Upper Siang, West Siang, and Dibang Valley Districts in **Arunachal Pradesh**
11.	**Pachmarhl (4981.72)**	03.03.1999	Part of Betul. Hoshangabad and Chhindwara Districts in **Madhya Pradesh**
12.	**Khangchendzonga (2619.92)**	07.02.2000	Part of North and West Districts in **Sikkim**

13.	**Agasthyamalai (3500.36)**	12.11.2001	Part of Thirunelveli and Kanyakumari Districts in **Tamil Nadu** and Thiruvananthapuram. Kollam and Pathanmthitta districts in **Kerala**.
14.	**Achanakmar-Amarkantak (3835.51)**	30.03.2005	Part of Anuppur and Dindori Districts of **Madhya Pradesh** and Bilaspur district of **Chhattisgarh**
15.	**Kachchh (12.454)**	29.01.2008	Part of Kachchh. Rajkot. Surendranagar and Patan Districts in **Gujarat**.
16.	**Cold Desert (7770)**	28.08.2009	Pin Valley National Park and surroundings: Chandratal and Sarchu and Kibber Wildlife sanctuary in **Himachal Pradesh**.
17.	**Seshachalam (4755.997)**	20.09.2010	Seshachalam hill ranges in Eastern Ghatsen compassing part of Chittoor and Kadapa Districts in **Andhra Pradesh**.
18.	**Panna (2998.98)**	25.08.2011	Part of Panna and Chhattarpur Districts in **Madhya Pradesh**.

6 Soils

Soil is the most important layer of the earth's crust. It is a valuable resource as it supports trees, grasses, crops and numerous lifeforms over the earth's surface. The bulk of food and clothing is derived from land-based crops that grow in the soil.

Formation of Soils:

- **Soil is the mixture of rock debris and organic materials** which develop on the earth's surface.
- The various agents of **weathering and gradation** have acted **upon the parent rock** material to produce a thin layer of soil.
- The major **factors affecting the formation** of soil are relief, parent material, climate, vegetation and other life-forms and time.
- **Human activities** also influence it to a large extent.
- **Components of the soil**: Mineral particles, humus, water and air.

Layers of Soils: Soil has three layers of soil which are called **horizons**. The **arrangement of layers** is known as the **soil profile.** Following are the layers of Soil:

- **Horizon A:** It is the **topmost zone**, where organic materials have got incorporated with the mineral matter, nutrients and water, which are necessary for the growth of plants.
- **Horizon B:** It is a **transition zone** between the 'horizon A' and 'horizon C', and contains matter derived from below as well as from above. It has **some organic matter** in it, although the mineral matter is noticeably weathered.
- **Horizon C:** It is composed of the **loose parent material.** This layer is the first stage in the soil formation process and eventually forms the above two layers.
- Underneath these three horizons is the rock which is also known as the **parent rock or the bedrock**.

Classification of Soils:

India has varied relief features, landforms, climatic realms and vegetation types. These have contributed to the development of various types of soils in India.

- In **ancient times**, soils used to be classified into two main groups – **Urvara and Usara**, which were fertile and sterile, respectively.
- In the **16th century A.D.**, soils were classified on the basis of their inherent characteristics and external features such as texture, colour, slope of land and moisture content in the soil.
- **Based on Texture**: The main soil types were identified as **sandy, clayey, silty and loam**, etc.
- **Basis of Colour**: They were red, yellow, black, etc.
- **Soil Survey of India**, established in 1956, made comprehensive studies of soils.
- The **Indian Council of Agricultural Research (ICAR)** has classified the Indian soils on the basis of their nature and character as per the United States Department of Agriculture (USDA) Soil Taxonomy.

Table: 6.1: Soil taxonomy classified by ICAR

S. No.	Order	Area (in thousand hectares)	Percentage
	Inceptisols	130372.90	39.74
	Entisols	92131.71	28.08
	Alfisols	44448.68	13.55
	Vertisols	27960.00	8.52
	Aridisols	14069.00	4.28
	Utisols	8250.00	2.51
	Mollisols	1320.00	0.40
	Others	9503.10	2.92
Total			**100**

Classification of Soil based on Genesis, Colour, Composition and Location:

- Alluvial soils
- Black soils
- Red and Yellow soils
- Laterite soils
- Arid soils
- Saline soils
- Peaty soils
- Forest soils

Alluvial Soils:

- They are widespread in the **northern plains** and the river valleys and cover **about 40 per cent** of the total area of the country.
- They are **depositional soils**, transported and deposited by rivers and streams.
- Through a narrow corridor in Rajasthan, they extend into the plains of Gujarat.

- In the Peninsular region, they are found in deltas of **the east coast and in the river valleys.**
- The alluvial soils vary in nature from **sandy loam to clay**.
- They are generally **rich in potash** but **poor in phosphorous.**
- In the Upper and Middle Ganga plain, two different types of alluvial soils have developed, viz. Khadar and Bhangar.
    - **Khadar** is the **new alluvium** and is deposited by floods annually, which enriches the soil by depositing fine silts.
    - **Bhangar** represents a system of **older alluvium**, deposited away from the flood plains. Both the Khadar and Bhangar soils contain calcareous concretions (Kankars).
- These soils are loamier and more clayey in the lower and middle Ganga plain and the Brahmaputra valley.
- The sand content decreases from the west to east.
- The colour varies from light grey to ash grey.
- Its shades depend on the depth of the deposition, the texture of the materials, and the time taken for attaining maturity.
- Alluvial soils are intensively cultivated.

Black Soil:

- It covers most of the **Deccan Plateau** which includes parts of Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and some parts of Tamil Nadu.
- In the upper reaches of the Godavari and the Krishna, and the north western part of the Deccan Plateau, the black soil is very deep.
- These soils are also known as the **'Regur Soil'** or the **'Black Cotton Soil'**.
- They are generally **clayey, deep and impermeable**.
- They **swell and become sticky** when **wet** and **shrink** when **dried**.
- During the dry season, these soils develop wide cracks. Thus, there occurs a kind of **'self-ploughing'**.
- Slow absorption and loss of moisture, the black soil **retains the moisture** for a very long time, which helps the crops, especially, the rain fed ones, to sustain even during the dry season.
- Chemically, the black soils are **rich in lime, iron, magnesia and alumina**. They also contain **potash**. But they **lack in phosphorous, nitrogen and organic matter**.
- The colour of the soil ranges from deep black to grey.

Red and Yellow Soil:

- Red soil develops on **crystalline igneous rocks** in areas of low rainfall in the eastern and southern part of the Deccan Plateau. Along the piedmont zone of the Western Ghat, long stretch of area is occupied by red loamy soil.
- Yellow and red soils are also found in parts of Odisha and Chhattisgarh and in the southern parts of the middle Ganga plain.
- The soil develops a **reddish colour** due to a wide **diffusion of iron** in crystalline and metamorphic rocks.
- It looks **yellow** when it occurs in a **hydrated form**.
- The fine-grained red and yellow soils are normally fertile, whereas coarse-grained

soils found in dry upland areas are poor in fertility.
- They are generally poor in nitrogen, phosphorous and humus.

Laterite Soil:
- Laterite has been derived from the Latin word 'Later' which means **brick**.
- It develops in **areas with high temperature and high rainfall.**
- These are the result of intense leaching due to tropical rains. With rain, lime and silica are leached away, and soils rich in iron oxide and aluminium compound are left behind.
- These soils are **poor in organic matter, nitrogen, phosphate and calcium**, **while iron oxide and potash are in excess.** Hence, laterites are not suitable for cultivation; however, application of manures and fertilisers are required for making the soils fertile for cultivation.
- Red laterite soils in Tamil Nadu, Andhra Pradesh and Kerala are more suitable for tree crops like **cashewnut**.
- Laterite soils are widely **cut as bricks** for use in house construction.
- These soils have mainly developed in the **higher areas of the Peninsular plateau**.
- The laterite soils are commonly found in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh and the hilly areas of Odisha and Assam.

Arid Soils:
- It ranges from red to brown in colour.
- They are generally sandy in structure and saline in nature.
- In some areas, the salt content is so high that **common salt is obtained** by evaporating the saline water.
- Due to the dry climate, high temperature and accelerated evaporation, they **lack moisture and humus**.
- **Nitrogen is insufficient** and **the phosphate content is normal.**
- **Lower horizons** of the soil are occupied by **'Kankars'** layers because of the increasing calcium content downwards. The 'Kankars' layer formation in the bottom horizons restricts the infiltration of water, and as such when irrigation is made available, the soil moisture is readily available for a sustainable plant growth.
- Arid soils are characteristically developed in western Rajasthan, which exhibit characteristic arid topography.
- These soils are poor and **contain little humus** and organic matter.

Saline Soils:
- They are also known as **Usara soils**.
- They contain a larger proportion of **sodium, potassium and magnesium**, and thus, they are **infertile**, and do not support any vegetative growth.
- They have **more salts**, largely because of dry climate and poor drainage.
- They occur in arid and semi-arid regions, and in waterlogged and swampy areas.
- Saline soils are more widespread in western Gujarat, deltas of the eastern coast and in Sundarban areas of West Bengal. In the Rann of Kuchchh, the Southwest Monsoon brings salt particles and deposits there as a crust.
- Seawater intrusions in the deltas promote the occurrence of saline soils.
- In the areas of intensive cultivation with excessive use of irrigation, especially

in areas of green revolution, the fertile alluvial soils are becoming saline.

- **Excessive irrigation** with dry climatic conditions promotes capillary action, which results in the deposition of salt on the top layer of the soil. In such areas, especially in Punjab and Haryana**,** farmers are advised to **add gypsum** to **solve the problem of salinity** in the soil.

Peaty Soil:

- They are found in the areas of **heavy rainfall** and **high humidity**, where there is a good growth of vegetation. Thus, large **quantity of dead organic matter** accumulates in these areas, and this gives **a rich humus and organic content to the soil**. Organic matter in these soils may go even up to 40-50 per cent.
- These soils are normally **heavy and black in colour**. At many places, they are alkaline also.
- It occurs widely in the Northern part of Bihar, Southern part of Uttarakhand and the coastal areas of West Bengal, Odisha and Tamil Nadu.

Forest Soil:

- They are formed in the forest areas where **sufficient rainfall** is available.
- The soils vary in structure and texture depending on the mountain environment where they are formed.
    - They are loamy and silty on valley sides and coarse-grained in the upper slopes.
- In the snow-bound areas of the Himalayas, they experience denudation, and are **acidic** with low humus content.
- The soils found in the **lower valleys are fertile**.

Soil Degradation:

- It can be defined as the **decline in soil fertility** when the **nutritional status declines** and **depth of the soil goes down** due to erosion and misuse.
- It is the main factor leading to the depleting soil resource base in India.
- The degree of soil degradation varies from place to place according to the topography, wind velocity and amount of the rainfall.

Soil Erosion:

- The **destruction of the soil cover** is described as soil erosion.
- The soil forming processes and the erosional processes of running water and wind go on simultaneously. But there is balance between this two as the rate of removal of fine particles from the surface is the same as the rate of addition of particles to the soil layer.
- Sometimes, such a balance is disturbed by **natural or human factors**, leading to a greater rate of removal of soil.
- Wind and water are powerful agents of soil erosion because of their ability to remove soil and transport it.
    - **Wind Erosion:** It is significant in **arid and semi-arid regions**.
    - **Water Erosion:** In regions with heavy rainfall and steep slopes, erosion by running water is more significant. It takes place mainly in:
        - **Sheet Erosion:** It takes place on **level lands** after a heavy shower and the soil removal is not easily noticeable. But it is harmful since it removes the finer and more fertile top soil.

- **Gully Erosion:** It is common on **steep slopes**. Gullies deepen with rainfall, cut the agricultural lands into small fragments, and make them unfit for cultivation. A region with a large number of **deep gullies or ravines** is called a **badland topography.** Ravines are widespread, in the Chambal basin and are also found in Tamil Nadu and West Bengal.

Reasons for Soil Erosion and Soil Degradation:

- **Soil Degradation in Indian Agriculture:** The salt lodged in the lower profiles of the soil comes up to the surface and destroys its fertility. Unless the soil gets enough humus, chemicals harden it and reduce its fertility in the long run.
- **Deforestation** effect on soil erosion is more in hilly parts of the country. Plants keep soils bound in locks of roots, and thus, prevent erosion.
- **Over-grazing** and shifting cultivation have affected the natural cover of land and given rise to extensive erosion.

Soil Conservation:

It is a methodology to maintain soil fertility, prevent soil erosion and exhaustion, and improve the degraded condition of the soil.

Measure for Soil Conservation: Soil erosion is essentially aggravated by faulty practices therefore following measures can be applied:

- Check open cultivable lands on slopes from farming. Lands with a slope gradient 15-20 percent should not be used for cultivation. Making terraces can be possible solution on hilly tracks.
- The issue of over grazing and shifting cultivation can be regulated and controlled by educating villagers about the consequences.
- Contour bunding, Contour terracing, regulated forestry, controlled grazing, cover cropping, mixed farming and crop rotation are some of the remedial measures which are often adopted to reduce soil erosion.
- Finger gullies can be eliminated by terracing. In bigger gullies, the erosive velocity of water may be reduced by constructing a series of check dams.
- Special attention should be made to control headward extension of gullies. This can be done by gully plugging, terracing or by planting cover vegetation.
- In arid and semi-arid areas, efforts should be made to protect cultivable lands from encroachment by sand dunes through developing shelter belts of trees and Agro-forestry.
- The Central Soil Conservation Board, set up by the Government of India, has prepared a number of plans for soil conservation in different parts of the country.
  - These plans are based on the climatic conditions, configuration of land and the social behaviour of people.

Unit: IV

Natural Hazards and Disasters: Causes, Consequences and Management

7 Natural Hazards and Disasters

Disasters in general and natural disasters in particular, are some such changes that are always disliked and feared by humankind. Disaster is an undesirable occurrence resulting from forces that are largely outside human control, strikes quickly with little or no warning, which causes or threatens serious disruption of life and property.

Natural Hazards:

- These are elements of circumstances in the Natural environment that have the **potential to cause harm** to people or property or both.
- These may be swift or permanent aspects of the respective environmental settings like currents in the oceans, steep slope and unstable structural features in the Himalayas or extreme climatic conditions in deserts or glaciated areas.

Natural Disaster:

- As compared to natural hazards**,** natural disasters are **relatively sudden** and cause large scale, widespread death, loss of property and disturbance to social systems and life over which people have a little or no control.
- Any event can be classed as disaster when the **magnitude of destruction** and **damage caused** by it is very **high**.
- Every disaster is unique in terms of the local socio-environmental factors that control it, the social response it generates, and the way each social group negotiates with it.

Issues regarding Disasters:

- The magnitude, intensity, frequency and damages caused by natural disasters have increased over the years.
- There is a growing concern among people the world over to deal with the menace created by these so that the loss of human life and property can be minimised.
- Significant changes have taken place in the pattern of natural disasters over the years.

Classification of Natural Disasters:

Identification and classification of disasters is being considered as an effective and scientific step to deal promptly and efficiently with the disasters. Broadly, natural disasters can be classified under four categories.

Natural Disasters and Hazards in India: India is vast and diverse in terms of its physical and socio-cultural attributes.

Earthquakes:

- Earthquakes are by far the **most unpredictable** and **highly destructive** of all the natural disasters.
- Earthquakes that are of **tectonic origin** have proved to be the **most devastating** and their **area of influence is also quite large**. It is series of earth movements brought about by a sudden release of energy during the tectonic activities in the earth's crust.
- Earthquakes associated with volcanic eruption, rock fall, landslides, subsidence, particularly in the mining areas, impounding of dams and

Table 7.1: Classification of Natural Disasters.

Atmospheric	Terrestrial	Aquatic	Biological
Blizzards	Earthquakes	Floods	Plants and Animals as colonisers (Locusts, etc.).
Thunderstorms	Volcanic Eruptions	Tidal Waves	Insect infestation- fungal, bacterial and viral diseases like bird flu, dengue etc.
Lightning	Landslides	Ocean Currents	
Tornadoes	Avalanches	Storm Surge	
Tropical cyclone	Subsidence	Tsunami	
Drought	Soil Erosion		
Hailstorms Frosts, Heatwave, or Loo, Cold wave etc			

reservoirs, etc. have limited area of influence and the scale of damage.

- The Indian plate is moving at a speed of one centimetre per year towards the north and north-eastern direction and this movement of plates is being constantly obstructed by the Eurasian plate from the north. Both the plates are said to be locked with each other resulting in accumulation of energy at different points of time.
    - Excessive accumulation of energy results in building up of stress, which ultimately leads to the breaking up of the lock and the sudden release of energy causes earthquakes along the Himalayan arch.
- **Most Vulnerable Areas**: Jammu and Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Sikkim, and the Darjeeling subdivision of West Bengal, and all the seven states of the northeast.

- The earthquake also occur on stable landmasses of peninsular region as energy build-up along the fault line represented by the river Bhima (Krishna) near Latur and Osmanabad (Maharashtra) and the possible breaking down of the Indian plate.

Earthquake Zones in India: National Geophysical Laboratory, Geological Survey of India, Department of Meteorology and National Institute of Disaster Management divided in following five earthquake zones.

- Very high damage risk zone
- High damage risk zone
- Moderate damage risk zone
- Low damage risk zone
- Very low damage risk zone

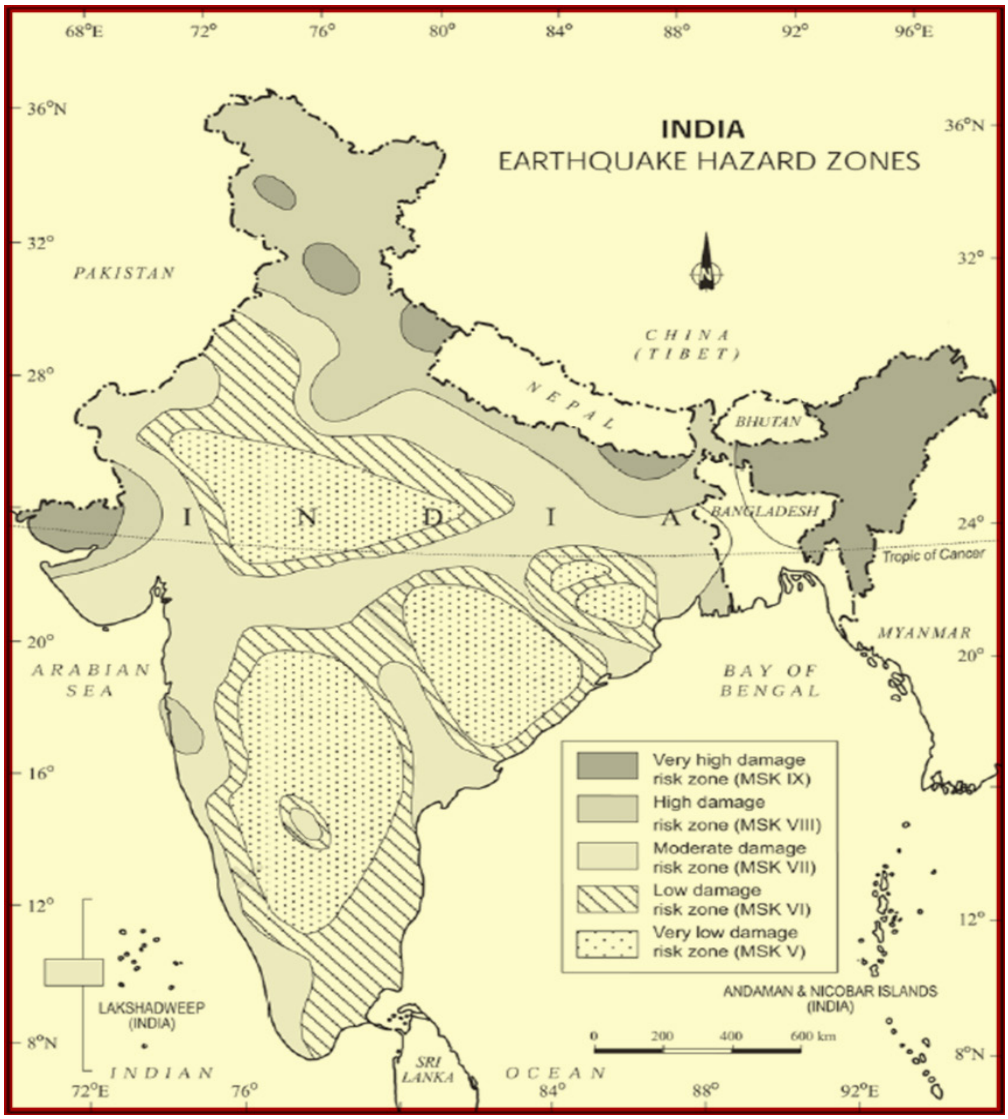

Figure 7.1: India: Earthquake Hazard Zones.

Out of these, the first two zones had experienced some of the most devastating earthquakes in India.

Very High Damage Risk Zone:

- North-east states, areas to the north of Darbhanga and Araria along the Indo-Nepal border in Bihar, Uttarakhand, Western Himachal Pradesh (around Dharamshala) and Kashmir Valley in the Himalayan region and the Kuchchh (Gujarat).

High Damage Risk Zone:

- The remaining parts of Jammu and Kashmir, Ladakh, Himachal Pradesh, Northern parts of Punjab, Eastern parts of Haryana, Delhi, Western Uttar Pradesh, and Northern Bihar.

Most of the areas that can be considered safe are from the stable landmass covered under the Deccan plateau.

Socio-Environmental Consequences of Earthquakes:

- It becomes a calamity when it strikes the areas of high density of population.
- It robs the population of their material and socio-cultural gains that they have preserved over generations.

Effects of the Earthquake: Earthquakes have all encompassing disastrous effects on the area of their occurrence.

- Surface seismic waves produce **fissures** on the upper layers of the earth's crust through which water and other volatile materials gush out, inundating the neighbouring areas.
- Earthquakes are also responsible for landslides and often these cause obstructions in the flow of rivers and channels resulting in the formation of reservoirs.
- Sometimes, rivers also change their course causing floods and other calamities in the affected areas.

Table 7.2: Effects of Earthquakes

On Ground	On Manmade Structures	On Water
Fissures	Cracking	Waves
Settlements	Slidings	Hydro-Dynamic Pressure
Landslides	Overturning	Tsunami
Liquefaction	Buckling	
Earth Pressure	Collapse	
Possible	Possible	Possible
Chain-effects	Chain-effects	Chain-effects

Earthquake Hazard Mitigation: Unlike other disasters, the damages caused by earthquakes are more devastating. It also destroys most of the transport and communication links, providing timely relief to the victims becomes difficult. The emphasis should be on disaster preparedness and mitigation rather than curative measures such as:

- Establishing earthquake monitoring centres (seismological centres) for regular monitoring and fast dissemination of information among the people in the vulnerable areas.
- Use of Geographical Positioning System (GPS) can be of great help in monitoring the movement of tectonic plates.
- Preparing a vulnerability map of the country and dissemination of vulnerability risk information among the people and educating them about the ways and means minimising the adverse impacts of disasters.
- Modifying the house types and building designs in the vulnerable areas and discouraging construction of high-rise buildings, large industrial establishments and big urban centres in such areas
- Finally, making it mandatory to adopt earthquake-resistant designs and use light materials in major construction activities in the vulnerable areas.

Tsunami:

Earthquakes and volcanic eruptions that cause the **seafloor to move abruptly** resulting in **sudden displacement of ocean water** in the form of **high vertical waves** are called tsunamis (harbour waves) or seismic sea waves.

- The seismic waves cause only one instantaneous vertical wave; but, after the initial disturbance, a series of after waves are created in the water that oscillate between high crest and low trough in order to restore the water level.
- The speed of wave in the ocean depends upon the depth of water. It is more in the shallow water than in the ocean deep. As result the **impact of tsunami is less over the ocean** and more near the coast where they cause large-scale devastations.
- It is difficult to detect a tsunami in the deeper parts of sea because over deep water the tsunami has very long wavelength and limited wave-height.
- When a tsunami enters shallow water, its wavelength gets reduced and the period remains unchanged, which increases the wave height. Thus, these are also called **Shallow Water Waves**.
- Tsunamis are frequently observed along the Pacific ring of fire, particularly along the coast of Alaska, Japan, Philippines, and other islands of Southeast Asia, Indonesia, Malaysia, Myanmar, Sri Lanka, and India etc.

Tropical Cyclones:

- Tropical cyclones are **intense low-pressure areas** confined to the area lying **between 30° N and 30° S latitudes**, in the atmosphere around which high velocity winds blow.
- **Horizontally,** it extends up to **500-1,000 km** and **vertically** from surface to **12-14 km**.
- A tropical cyclone or hurricane is like a **heat engine** that is energised by the release of latent heat on account of the

condensation of moisture that the wind gathers after moving over the oceans and seas.

- **Initial conditions for the emergence of a Tropical Cyclone**:
  - Large and continuous supply of **warm and moist air** that can release enormous latent heat.
  - **Strong Coriolis force** that can prevent filling of low pressure at the centre (absence of Coriolis force near the equator prohibits the formation of tropical cyclone between 0° -5° latitude).
  - **Unstable condition** through the troposphere that creates local disturbances around which a cyclone develops.
  - Finally, **absence of strong vertical wind wedge**, which disturbs the vertical transport of latent heat.

Structure of the Tropical Cyclone:

- They are characterised by large pressure gradients.
- The centre of the cyclone is mostly a warm and low-pressure, cloudless core known as **eye of the storm**.
- Generally, the isobars are closely placed to each other showing high-pressure gradients. Normally, it varies between 14-17mb/100 km, but sometimes it can be as high as 60mb/100km.
- Expansion of the wind belt is about 10-150 km from the centre.

Spatial-Temporal distribution of the Tropical Cyclone:

- Owing to its Peninsular shape surrounded by the Bay of Bengal in the east and the Arabian Sea in the west, the tropical cyclones in India also originate in these two important locations.
- The cyclones originate **between 10°-15° north** latitudes during the monsoon season.
- In case of the Bay of Bengal, cyclones mostly develop during the months of October and November. They originate between 16°-2° N latitudes and to the west of 92° E.

Consequences of Tropical Cyclones:

- In India, the force of the cyclone decreases with increase in distance from the Bay of Bengal and the Arabian Sea. So, the coastal areas are often struck by severe cyclonic storms with an average velocity of 180 km/h. Often, this results in **abnormal rise in the sea level known as Storm Surge.**

Surge: A surge is generated due to interaction of air, sea and land. The cyclone provides the driving force in the form of very high horizontal pressure-gradient and very strong surface winds. The sea water flows across the coast along with strong winds and heavy downpour.

- This results in inundation of human settlements, agricultural fields, damaging crops and destruction of structures created by human beings.

Floods:

Inundation of land and human settlements by the rise of water in the channels and its spill-over presents

the condition of flooding. The causes of floods are well-established.

- They occur commonly when water in the form of surface run-off exceeds the carrying capacity of the river channels and streams and flows into the neighbouring low-lying flood plains.
- Floods are relatively slow in occurrences and often, occur in well-identified regions and within expected time in a year.
- Floods can also be caused due to a storm surge (in the coastal areas), high intensity rainfall for a considerably longer time period, melting of ice and snow, reduction in the infiltration rate and presence of eroded material in the water due to higher rate of soil erosion.
- Floods in the South, Southeast and East Asian countries, particularly in China, India and Bangladesh, are frequent and equally disastrous.
- Rastriya Barh Ayog (National Flood Commission) identified 40 million hectares of land as flood-prone in India.
- **High Flood-Prone States:** Assam, West Bengal and Bihar.
- The states like Punjab and Uttar Pradesh, are vulnerable to occasional floods.
- The states like Rajasthan, Gujarat, Haryana and Punjab are also getting inundated in recent decades due to flash floods.

Spread of Floods by Humans:

Indiscriminate deforestation, unscientific agricultural practices, disturbances along the natural drainage channels and colonisation of floodplains and river-beds are some of the human activities that play an important role in increasing the intensity, magnitude and gravity of floods.

Consequence and Control of Floods

Negative Impacts of Floods:

- There is frequent inundation of agricultural land and human settlement and have serious consequences on the national economy and society.
- Floods destroy valuable crops, damage physical infrastructure such as roads, rails, bridges and human settlements.
- Millions of people are rendered homeless and are also washed down along with their cattle in the floods.

Positive Aspect of Floods:

- Every year, floods deposit fertile silt over agricultural fields which is good for the crops.
- **Majuli (Assam)**, the **largest riverine island** in the world, is the best example of good paddy crops after the annual floods in Brahmaputra.

Solutions:

- Construction of flood protection embankments in the flood-prone areas, construction of dams, afforestation and discouraging major construction activities in the upper reaches of most of the flood-creating rivers, etc.
- Removal of human encroachment from the river channels and depopulating the flood plains can be the other steps.

Droughts:

The term 'drought' is applied to an extended period when there is a shortage of water availability due to inadequate precipitation, excessive

rate of evaporation and over-utilisation of water from the reservoirs and other storages, including the ground water.

Types of Drought:

- **Meteorological Drought:** It is a situation when there is a prolonged period of inadequate rainfall marked with mal distribution of the same over time and space.
- **Agricultural Drought:** It is also known as soil moisture drought, characterised by low soil moisture that is necessary to support the crops, thereby resulting in crop failures. Moreover, if an area has more than 30 per cent of its gross cropped area under irrigation, the area is excluded from the drought-prone category.
- **Hydrological Drought:** It results when the availability of water in different storages and reservoirs like aquifers, lakes, reservoirs, etc. falls below what the precipitation can replenish.
- **Ecological Drought:** When the productivity of a natural ecosystem fails due to shortage of water and as a consequence of ecological distress, damages are induced in the ecosystem.

Drought Prone Areas in India:

- Nearly 19 per cent of the total geographical area of the country and 12 per cent of its total population suffer due to drought every year.
- About 30 per cent of the country's total area is identified as drought prone affecting around 50 million people.

On the basis of severity of droughts, India can be divided into the following regions:

- **Extreme Drought Affected Areas:** Most parts of Rajasthan, particularly areas to the west of the Aravali hills, i.e., Marusthali and Kachchh regions of Gujarat fall in this category. The districts like Jaisalmer and Barmer receive less than 90 mm average annual rainfall.
- **Severe Drought Prone Area:** Parts of eastern Rajasthan, most parts of Madhya Pradesh, eastern parts of Maharashtra, interior parts of Andhra Pradesh and Karnataka Plateau, northern parts of interior Tamil Nadu and southern parts of Jharkhand and interior Odisha.
- **Moderate Drought Affected Area**: Northern parts of Rajasthan, Haryana, southern districts of Uttar Pradesh, the remaining parts of Gujarat, Maharashtra except Konkan, Jharkhand and Coimbatore plateau of Tamil Nadu and interior Karnataka.

Consequences of Drought:

- **Cascading Effects:** Crop failure leading to scarcity of food grains (akal), fodder (trinkal), inadequate rainfall, resulting in shortage of water (jalkal), and often shortage in all the three (trikal) is most devastating.
- Large-scale death of cattle and other animals, migration of humans and livestock.
- Scarcity of water compels people to consume contaminated water resulting in spread of many **waterborne diseases** like gastro-enteritis, cholera, hepatitis, etc.

Steps to improve Conditions:

- Provision for the distribution of safe drinking water, medicines for the victims

Figure 7.2: Drought Prone Areas.

and availability of fodder and water for the cattle and shifting of the people and their livestock to safer places.

- Identification of ground water potential in the form of aquifers, transfer of river water from the surplus to the deficit areas, and particularly planning for inter-linking of rivers and construction of reservoirs and dams, etc. should be given a serious thought.

- Remote sensing and satellite imageries can be useful in identifying the possible river-basins that can be inter-linked and in identifying the ground water potential.
- Rainwater harvesting can also be an effective method in minimising the effects of drought.

Landslide:

It is the rapid sliding of large mass of bedrocks. Disasters due to landslides, are in general, far less dramatic than due to earthquakes, volcanic eruptions, tsunamis and cyclones but their impact on the natural environment and national economy is in no way less severe.

- Landslides are largely controlled by highly localised factors.
- The gathering information and monitoring the possibilities of landslide is not only difficult but also immensely cost-intensive.
- On the basis of past experiences, frequency and certain causal relationships with the controlling factors like geology, geomorphic agents, slope, land-use, vegetation cover and human activities, India has been divided into a number of zones.

Landslide Vulnerability Zones:

- **Very High Vulnerability Zone:** These areas are Highly unstable like, relatively young mountainous areas in the Himalayas and Andaman and Nicobar, high rainfall regions with steep slopes in the Western Ghats and Nilgiris, the north-eastern regions, along with areas that experience frequent ground-shaking due to earthquakes, etc. and areas of intense human activities, particularly those related to construction of roads, dams, etc.
- **High Vulnerability Zone:** Areas that have almost similar conditions to those included in the very high vulnerability zone are also included in this category. The only difference between these two is the combination, intensity and frequency of the controlling factors. All the Himalayan states and the states from the north-eastern regions except the plains of Assam are included in the high vulnerability zones.
- **Moderate to Low Vulnerability Zone**: Areas that receive less precipitation such as Trans-Himalayan areas of Ladakh and Spiti (Himachal Pradesh), undulated yet stable relief and low precipitation areas in the Aravali, rain shadow areas in the Western and Eastern Ghats and Deccan plateau also experience occasional landslides. Landslides due to mining and subsidence are most common in states like Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Goa and Kerala.

Consequences of Landslides:

- They have relatively small and localised area of direct influence, but roadblock, destruction of railway lines and channel blocking due to rock-falls have far-reaching consequences.
- Diversion of river courses due to landslides can also lead to flood and loss of life and property.

Mitigation:

- It is always advisable to adopt **area-specific measures** to deal with landslides.

- Restriction on the construction and other developmental activities such as roads and dams, limiting agriculture to valleys and areas with moderate slopes, and control on the development of large settlements in the high vulnerability zones, should be enforced.
- Some positive actions like promoting large-scale afforestation programmes and construction of bunds to reduce the flow of water.
- Terrace farming should be encouraged in the north-eastern hill states where Jhumming (Slash and Burn/Shifting Cultivation) is still prevalent.

Disaster Management:

- Disasters due to cyclones, unlike the ones caused by earthquakes, tsunamis and volcanic eruptions are more predictable in terms of the time and place of their occurrences.
- Construction of cyclone shelters, embankments, dykes, reservoirs and afforestation to reduce the speed of the winds are some of the steps that can help in minimising the damages.

Steps for Disaster Management:

- All hazards need not turn into disasters since it is difficult to eliminate disasters, particularly natural disasters. Then the next best option is mitigation and preparedness.
- There are three stages involved in disaster mitigation and management:
  - **Pre-disaster management** involves generating data and information about the disasters, preparing vulnerability zoning maps and spreading awareness among the people about these. Apart from these, disaster planning, preparedness and preventive measures are other steps that need to be taken in the vulnerable areas.
  - **During disasters**, rescue and relief operations such as evacuation, construction of shelters and relief camps, supplying of water, food, clothing and medical aids etc. should be done on an emergency basis.
  - **Post-disaster operations** should involve rehabilitation and recovery of victims. It should also concentrate on capacity building in order to cope up with future disasters.
- Introduction of the Disaster Management Bill, 2005 and establishment of National Institute of Disaster Management are some examples of the positive steps taken by the Government of India.

Interesting Points:

- The **Disaster Management Bill, 2005**, defines disaster as a catastrophe, mishap, calamity or grave occurrence affecting any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, environment, and is of such nature or magnitude as to be beyond the coping capacity of the community of the affected area.
- Establishment of National Institute of Disaster Management, India, Earth Summit at Rio de Janeiro, Brazil, 1993 and **Sendai framework** for **disaster risk reduction** was signed in 2015.